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AUTHOR Dei Rossi, J. A.; And Others
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ABSTRACT

Two specific applications for networks might be used to serve the biomedical community: (1) networking of the nation's educational television (ETV) stations for occasional or one-time broadcasting and (2) networking of the nation's medical schools for continuous broadcasting. These two applications are analyzed in detail. A second contribution of this analysis is the provision of data and methodology for examining costs and effectiveness (in terms of physicians and students within broadcasting range) of configurations of subsets of points in the full network. The data and methodology could also be used for determining the minimum cost for networks using media other than broadband television broadcasting, such as audio only broadcasting in conjunction with slides or still pictures. The cost attractiveness of networked, simultaneous broadcasting can also be compared with, for example, sequential broadcasting using mailed video tapes. (NH)

MEMORANDUM
RM-6204-NLM
FEBRUARY 1970

A COST ANALYSIS OF MINIMUM DISTANCE TV NETWORKING FOR BROADCASTING MEDICAL INFORMATION

J. A. Dei Rossi, R. S. Heiser and N. S. King

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The RAND Corporation
1700 MAIN ST • SANTA MONICA • CALIFORNIA • 90406

PREFACE

The Lister Hill National Center for Biomedical Communications of the National Library of Medicine (NLM) has been appointed by the Board of Regents of the NLM to assume the responsibility for the development of, and the coordinated planning for, Biomedical Communications. At the request of the Center, Rand has undertaken the examination of broadband telecommunication systems in biomedical communications. This Memorandum documents the initial analysis of one application of this mode of communication utilizing common carrier land lines for networking. It is part of Rand's effort for the Center in the analysis of various applications of technology to the needs of biomedical information dissemination.

SUMMARY

This Memorandum deals with the problem of estimating the cost of networking the TV broadcasting of biomedical information, using common carrier land lines. Such networking costs are made up of three components: interexchange channel costs based on the intercity distances between broadcast points and the number of hours of broadcasting; a station connection charge for a switching connection between the broadcast point and the local common carrier facility, which includes both a fixed charge and a charge based on the number of hours of use; and local channel charges for connecting the broadcast point and the local facility.

To estimate the costs efficiently, using these charge rates, it was necessary to calculate minimum distance networks for connecting the points in each network. Such a network is generally known as a "minimal weighted spanning tree." In this case, the weights are the distances between broadcast points. The algorithm for these calculations was programmed for computers and provides the basic framework for the cost estimates.

Two major networking applications were considered: the networking on a national basis of existing educational television (ETV) stations and the networking, also on a national basis, of accredited medical schools. The first provides the cost of one-time (occasional) broadcasts aimed primarily at the biomedical community. The second provides the networking cost of a national closed circuit TV network for the nation's medical schools.

The ETV network was defined to include only ETV stations with at least one Standard Metropolitan Statistical Area (SMSA) within broadcast range to assure a sufficiently large audience. Also, data on physician population by SMSA are available, which makes it possible to calculate some measure of potential audience size.

With the data available, it was found that approximately 96.7 percent of the SMSA physician population could be reached by 106 ETV stations. Further, it was found that because there was a very uneven distribution of physicians among these SMSAs, about 90 percent of

this population could be reached by about 49 percent, or 52, of the largest stations.

The networking of the full 106 ETV stations, using the minimum distance network, requires about 12,000 miles of intercity line. The cost per hour is approximately $80,000 for a 1-hour broadcast and $27,000 per hour for a 5-hour broadcast. Using an active physician population within range of this network of 260,160 (1970 estimate), the network cost per potential viewer-hour then ranges from 30 cents for the 1-hour broadcast to 11 cents for the 5-hour broadcast.

The second application, the full medical school network, contains 97 schools and requires about 10,000 miles of intercity line at a cost of approximately $600,000 per month. This network, however, buys about 160 hours of networking time per month and reaches about 85,000 biomedical students. Thus, the networking cost per month per school is approximately $6000, the networking cost per month per student is $7, and the networking cost per potential viewer-hour is 5 cents.

These cost figures are predicated on the assumption of a 15-mile average local channel distance and physician population projections described in the text. The sensitivity of the costs to the local channel distance was tested and found not to be very great. The physician population projections are considered reasonably accurate, and since the annual increments in the total population are small relative to the total population, errors in this estimate should have minor impacts.

The cost estimates for the specific configurations described in this study have not been verified with the telephone company, since the purpose of this study is not to determine the precise cost of an in-place system. The purpose is to provide a reasonably accurate assessment of the cost and potential benefit of TV networking as a mode of disseminating information to the biomedical community. These data can also be used for purposes of comparison and planning involving alternative modes of information dissemination.

ACKNOWLEDGMENTS

The authors wish to express their gratitude to D. R. Fulkerson of The Rand Corporation for first suggesting the use of the "minimal weighted spanning tree" algorithm used to calculate the minimal distance networks used in this Memorandum.

CONTENTS

I. INTRODUCTION

This Memorandum deals with the problem of land-line, or telephone circuit, networking for the broadcasting of biomedical information. In more specific terms, the Memorandum addresses the problem of finding minimum distance networks for n given points in which a particular point in the network broadcasts to the remaining $n - 1$ points. Such a minimum distance network, utilizing telephone company circuits, will, in turn, be a minimum cost network.

In addition to describing the algorithm for finding the minimum distance network for any n points, two specific applications for networks that might be used to serve the biomedical community are analyzed in detail. The first is networking of the nation's educational television (ETV) stations for occasional, or one-time, broadcasting. The second is the networking of the nation's medical schools for continuous broadcasting.

The first application is intended to indicate both the potential for coverage of the physician population and the networking cost of one-time broadcasts to the medical community using ETV. The second application shows the networking cost of closed circuit TV networks for the nation's medical schools. A second contribution of this analysis is the provision of data and methodology for examining costs and effectiveness (measured in terms of physicians and students within broadcast range) of configurations of subsets of points in the full network.

It is important to emphasize that the data and methodology could also be used for determining the minimum cost for networks using media other than broadband television broadcasting. For example, one might use such networks for broadcasting audio only, in conjunction with slides or still pictures. Finally, the cost attractiveness of networked, simultaneous broadcasting can be compared with, for example, sequential broadcasting using mailed video tapes.

In what follows, there is first a brief description of the methodology used to determine the minimum distance network for each set of points considered. Then the specific cities for the ETV networks

are described. This is followed by a description of the AT&T rates for networking, cost estimates for the networks, and a brief discussion of the cost. The procedure is then repeated for the medical school networks.

II. MINIMUM DISTANCE NETWORK CONFIGURATIONS

Most communication-system-design problems are more difficult to solve than the broadcast network problem addressed here. For example, in a message-switching communication system, line loads must be balanced and response times through queues calculated. In the broadcast network problem, it is possible to take advantage of the homogeneity of the network traffic and to define it as a problem capable of strict optimization. The broadcast network is an inherently efficient way to "use" lines; the broadcast message utilizes all the capacity of all lines without overloading any line and there are no illegal concentrations or unbalancings. Thus, the optimizing problem is simply one of minimizing the total line miles. This minimum distance network is, in turn, a minimum cost network.

A minimum distance network over n points is a "tree." A tree is a connected graph that has no circuits. This means that there are no multiple edges and that there is only one path connecting any pair of points. A tree over n points has $n - 1$ edges. If we were to draw a network with more than $n - 1$ edges, then multiple paths must exist between some points and the network would not be optimal.

Now, there is not just one tree over n points. There are, in fact, n^{n-2} different trees. This is unwieldy for large n. For example, the number of trees for 100 points is 10^{196} [= $(10^2)^{98}$]. Thus, brute-force enumeration and trial of these trees would be out of the question. Fortunately, there is a theorem* that guarantees that it is possible to find a minimum distance tree in fewer tries. This theorem provides us with a simple "economy rule": We begin with the least expensive link, forming a tree over two of the points. Thereafter, we add the least expensive link between a point *in* the tree and a point *outside* the tree. After repeating this process until $n - 1$ links have been drawn we are assured that we have drawn a minimum distance tree. During this process, $(k)(n - k)$ comparisons must be made when k points

*O. Ore, *Graphs and Their Uses*, Random House, New York, 1963, pp. 38-40.

are already connected, so a total of

$$\sum_{k=1}^{n-1} k(n - k) \simeq \int_{1}^{n-1} k(n - k)\ dk = \left(\frac{n^3}{6} - n\right)$$

trials are needed to solve the problem using this technique. This is approximately 166,000 (1.66×10^5) trials for 100 points, considerably fewer than a comparison of all possible trees.*

The general name given to the type of tree we are using in this paper for the network configurations is a "minimal weighted spanning tree." In this application the weights used are the distances in airline miles between the points included in the tree. The JOSS† program used for the calculations is shown in Appendix A. This program calculates the distances between any two cities i and j from the vertical (V) and horizontal (H) coordinates of each city using the following formula:

$$\sqrt{\frac{(V_i - V_j)^2 + (H_i - H_j)^2}{10}}$$

The coordinates used in this formula (see Tables 1 and 2) are not the standard geographical coordinates of the cities but, rather, the coordinates of points in a plane onto which the points on the earth's spherical surface have been transformed. For this reason, the above formula, which disregards the curvature of the earth's surface, can be used. The number 10 in the denominator is simply an arbitrary scaling factor used in the transformation. With these V and H coordinates and

*Note that this is different from the "traveling salesman problem" of forming the minimal path (line series) through n points. Although there are fewer paths than trees, namely $(n - 1)$ factorial, no completely satisfactory computational method has been developed to find the optimal path. For example, for 100 points there are 9×10^{153} paths and a very substantial number of these must be inspected to approach optimality.

†JOSS is the trademark and service mark of The Rand Corporation for its computer programs and services using that program.

the above formula, the official airline distance between cities approved by the FCC for applying telephone company rates can be obtained with the JOSS Program in Appendix A for any given set of cities.

III. ETV NETWORKING

As of December 31, 1966, there were 272,891 non-Federal (those not employed by the Federal Government) physicians in the United States (including Hawaii and Alaska) and its possessions.* Of these, 230,518, or 84.5 percent, were located in the 300 Standard Metropolitan Statistical Areas (SMSAs) in the U.S.† Since data on the distribution of physicians at the city level are available only for physicians in SMSAs and since such a large percentage of the total physician population appears to reside in these areas, the ETV network described here is restricted to only those stations that reach at least one SMSA.

By the end of 1969, there were 183 ETV stations in the U.S., excluding Alaska and Hawaii.‡ Of these, 45 stations in five separate states are included in statewide ETV networks.** Each statewide network can be included in the larger network by a single connection. Thus, all 183 stations can be reached by connecting 143 of the stations. Further, 17 of the stations are in eight cities with more than one ETV station†† so that the total area that could be reached by ETV can be reached by connecting only 134 stations. Of the 134 distinct stations that would be candidates for inclusion in a full nationwide ETV network, 106, or 79 percent, of the stations are in or around SMSAs. These 106 ETV stations reach 96.7 percent of all non-Federal physicians listed as being in SMSAs.

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* *Distribution of Physicians, Hospitals and Hospital Beds in the U.S.*, Vol. 2, Metropolitan Areas, American Medical Association, Chicago, 1966.

† Ibid. The list of 300 also includes what are called "potential" SMSAs. This definition of the SMSAs is that of Sales Management, Inc., rather than the U.S. Office of Statistical Standards.

‡ *1969 Directory and Yearbook of Educational Broadcasting*, National Association of Educational Broadcasters, Washington, D.C., 1969.

** The state networks are Alabama, 8 stations; Georgia, 10 stations; Kentucky, 13 stations; South Carolina, 5 stations; and Nebraska, 9 stations.

†† New York City has 3 stations; Miami, Chicago, Boston, Minneapolis-St. Paul, Pittsburgh, Richmond, and Milwaukee have 2 each.

Two steps were taken to determine the number of SMSAs reached by each TV station and the potential physician audience at each of these stations. First, a complete list of SMSAs, by state, with the number of non-Federal physicians in each SMSA was compiled. Next, the location of all ETV stations in the U.S. was determined and the following rule applied: All SMSAs within 50 miles of a UHF ETV station, or within 75 miles of a VHF station, were counted as being in the broadcast range of that station.

This rule is somewhat arbitrary since the radius of range is not generally constant for any given station or the same among stations. However, the rule is adequate for the purposes of this study since total cost is not affected by these figures and accurate data for the distribution of the potential physician audience are available only for SMSAs. This latter fact limits the usefulness of a more accurate analysis of the actual radius of each station. The rule of 50 and 75 miles is, perhaps, a bit generous, but this should offset the fact that there are undoubtedly some physicians within the broadcast range of some of the ETV stations who do not reside in SMSAs and, thus, have not been counted in the SMSAs' population total.

The complete list of locations of the 106 ETV stations with their *V* and *H* coordinates, is shown in Table 1, together with the rank of that station measured in terms of the number of non-Federal physicians residing within broadcast range. A full listing of all the SMSAs in the range of each station, the physician population within SMSAs, and the total number of physicians per ETV station is shown in Appendix B. The cumulative frequency distribution of this population plotted against the ETV stations in descending order of rank is shown in Fig. 1. It is important to note that this is the cumulative distribution of the total physicians reached (230,518), not the total non-Federal physician population (272,891).

Using the *V* and *H* coordinates in Table 1 and the JOSS program in Appendix A, the minimum distance networks for all 106 stations and the largest (lowest rank) 5, 10, 15, 20, and 52 ETV stations were calculated. The results of these calculations provide the total miles for each set of stations, the total population reached, and the percentage of the total within reach as shown in Table 2.

Table 1

VERTICAL AND HORIZONTAL COORDINATES OF 106 ETV STATIONS REACHING AT LEAST ONE STANDARD METROPOLITAN STATISTICAL AREA (SMSA), RANKED BY SIZE

ETV Stations	*Rank (largest to smallest)*	*Coordinates*	
		Vertical	*Horizontal*
New York, N.Y.	1	4997	1406
Los Angeles, Calif.	2	9213	7878
Chicago, Ill.	3	5986	3426
Philadelphia, Pa.	4	5251	1458
Boston, Mass.	5	4422	1249
San Francisco, Calif.	6	8492	8719
Detroit, Mich.	7	5536	2828
Cleveland, Ohio	8	5574	2543
Washington, D.C.	9	5622	1583
Atlanta, Ga.[a]	10	7260	2083
Pittsburgh, Pa.	11	5621	2185
Baltimore, Md.	12	5510	1575
St. Paul, Minn.	13	5777	4513
Miami, Fla.	14	8351	0527
St. Louis, Mo.	15	6807	3482
Louisville, Ky.[a]	16	6529	2772
Houston, Tex.	17	8938	3536
Birmingham, Ala.[a]	18	7518	2446
Dallas, Tex.	19	8436	4034
Seattle, Wash.	20	6336	8896
Milwaukee, Wis.	21	5788	3589
Hartford, Conn.	22	4687	1373
Denver, Colo.	23	7501	5899
New Orleans, La.	24	8483	2638
San Jose, Calif.	25	8583	8619
Buffalo, N.Y.	26	5075	2326

Table 1--continued

ETV Stations	*Rank (largest to smallest)*	*Coordinates*	
		Vertical	*Horizontal*
Cincinnati, Ohio	27	6263	2679
Charleston, S.C.[a]	28	7021	1281
East Lansing, Mich.	29	5584	3081
Chapel Hill, N.C.	30	6361	1511
Kansas City, Mo.	31	7027	4203
San Diego, Calif.	32	9468	7629
New Haven, Conn.	33	4792	1342
Bloomington, Ind.	34	6417	2984
Omaha, Nebr.[a]	35	6687	4595
Portland, Oreg.	36	6799	8914
Tampa, Fla.	37	8173	1147
Columbus, Ohio	38	5972	2555
Rochester, N.Y.	39	4913	2195
Syracuse, N.Y.	40	4798	1990
Hershey, Pa.	41	5337	1704
Schenectady, N.Y.	42	4629	1675
San Bernardino, Calif.	43	9172	7710
Sacramento, Calif.	44	8304	8580
Bridgeport, Conn.	45	4841	1360
Austin, Tex.	46	9005	3996
Memphis, Tenn.	47	7471	3125
Providence, R.I.	48	4550	1219
Phoenix, Ariz.	49	9135	6748
Richmond, Va.	50	5906	1472
Oklahoma City, Okla.	51	7947	4373
Oxford, Ohio	52	6204	2759
Nashville, Tenn.	53	7010	2710
Madison, Wis.	54	5887	3796
Salt Lake City, Utah	55	7576	7065
Toledo, Ohio	56	5704	2820

Table 1--continued

ETV Stations	*Rank (largest to smallest)*	*Coordinates*	
		Vertical	*Horizontal*
Sneedville, Tenn.	57	6632	2205
Norfolk, Va.	58	5918	1223
Orlando, Fla.	59	7954	1031
Conway, Ark.	60	7668	3508
Allentown, Pa.	61	5166	1585
Wilmington, Del.	62	5326	1485
Scranton, Pa.	63	5042	1715
St. John, Ind.	64	6057	3358
Jacksonville, Fla.	65	7649	1276
Huntington, W. Va.	66	6212	2299
Charlotte, N.C.	67	6657	1698
Jackson, Miss.	68	8035	2880
Tucson, Ariz.	69	9345	6485
Binghamton, N.Y.	70	4943	1837
Urbana, Ill.	71	6371	3336
Tulsa, Okla.	72	7707	4173
Corvallis, Oreg.	73	7016	8991
Erie, Pa.	74	5321	2397
Albuquerque, N. Mex.	75	8549	5887
Roanoke, Va.	76	6196	1801
Spokane, Wash.	77	6247	8180
Pueblo, Colo.	78	7787	5742
Augusta, Maine	79	3961	1370
Tacoma, Wash.	80	6415	8906
Gainesville, Fla.	81	7838	1310
Des Moines, Iowa	82	6471	4275
Burlington, Vt.	83	4270	1808
Topeka, Kans.	84	7110	4369
Duluth, Minn.	85	5352	4530
Mt Pleasant, Mich.	86	5438	3206
Norwich, Conn.	87	4668	1263

Table 1--continued

ETV Stations	*Rank (largest to smallest)*	*Coordinates*	
		Vertical	*Horizontal*
Vincennes, Ind.	88	6588	3082
Fargo, N.D.	89	5615	5182
Durham, N.H.	90	4276	1341
Nashville, N.C.	91	6749	2001
Las Vegas, Nev.	92	8665	7411
Pensacola, Fla.	93	8147	2200
Lubbock, Tex.	94	8598	4962
Athens, Ohio	95	6011	2354
Ogden, Utah	96	7480	7100
Concord, N.C.	97	6601	1679
Bowling Green, Ohio	98	5764	2804
Yakima, Wash.	99	6553	8607
Vermillion, S.D.	100	6443	4869
Brookings, S.D.	101	6129	4972
Provo, Utah	102	7680	7006
Orono, Maine	103	3754	1323
Tallahassee, Fla.	104	7877	1716
Newark, Ohio	105	5904	2480
Rapid City, S.C.	106	6518	5903

SOURCE: American Telephone and Telegraph Co., Long Lines Department, *Administrative Rates and Tariffs*, Tariff FCC No. 255, New York, 1966.

[a]Denotes statewide ETV Network.

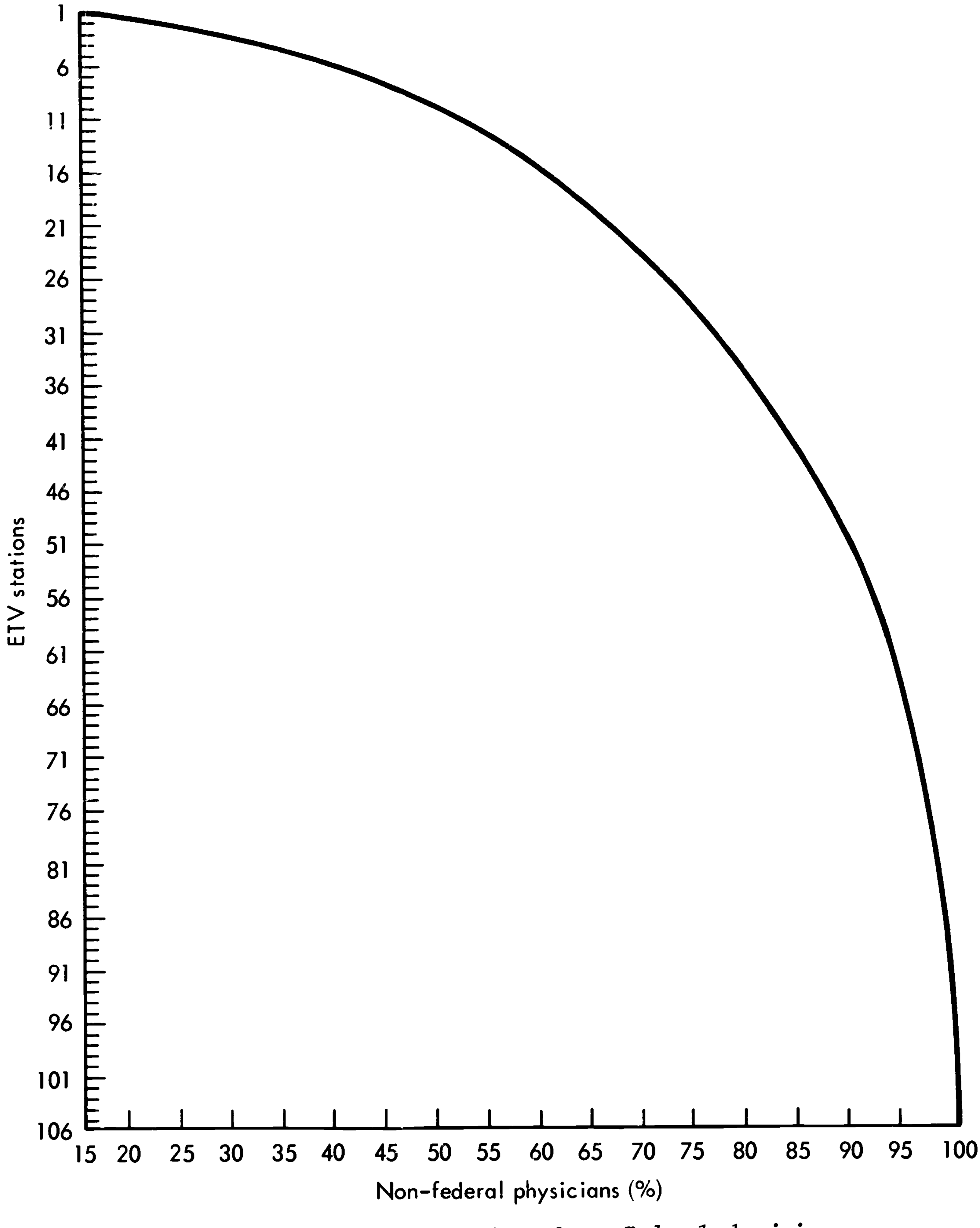

Fig. 1--Cumulative distribution of non-Federal physicians reached by the 106-ETV-station network

Table 2

COVERAGE OF VARIOUS SIZE ETV NETWORKS

Number of ETV Stations	*Total Miles*[a]	*Physician Population Reached*[b]	*Percent of Total Population*
5	2,674	81,942	36.6
10	3,656	111,743	50.0
15	4,575	131,716	58.9
20	5,981	146,232	65.4
52	8,397	200,620	89.7
106	12,031	223,583	100.0

[a]Includes only miles from program operating center o program operating center in each city.

[b]Based on the 1966 non-Federal physician population in SMSAs.

The printouts of thes^ runs showing the links in each network, the intermediate numbers of miles and physicians reached, and miles per physician reached are in Appendix D. A map of the full 106-city network is shown in Fig. 2.

The stations were stored in the computer in descending order of audience size. Thus, networks for the *N* largest population centers can be calculated by truncating the list after *N*. Any *N* solution obtained represents the least expensive way to network the full audience in that particular subset of cities. The subset selected, however, is not necessarily that which gives the absolute minimum cost for a given audience size. Finding such a subset poses an entirely different analytical problem. In addition, such a result might omit logically important cities or regions.

The map does r^t show networks in the following states: Alaska, Montana, Wyoming, New Jersey, Idaho, and Hawaii. The first three, Alaska, Montana, and Wyoming, have no ETV stations. New Jersey has no ETV station, but its cities are served by stations in New York City and Philadelphia. Idaho has an ETV station at Moscow, but there is no SMSA or medical school within the broadcast range. Hawaii has a

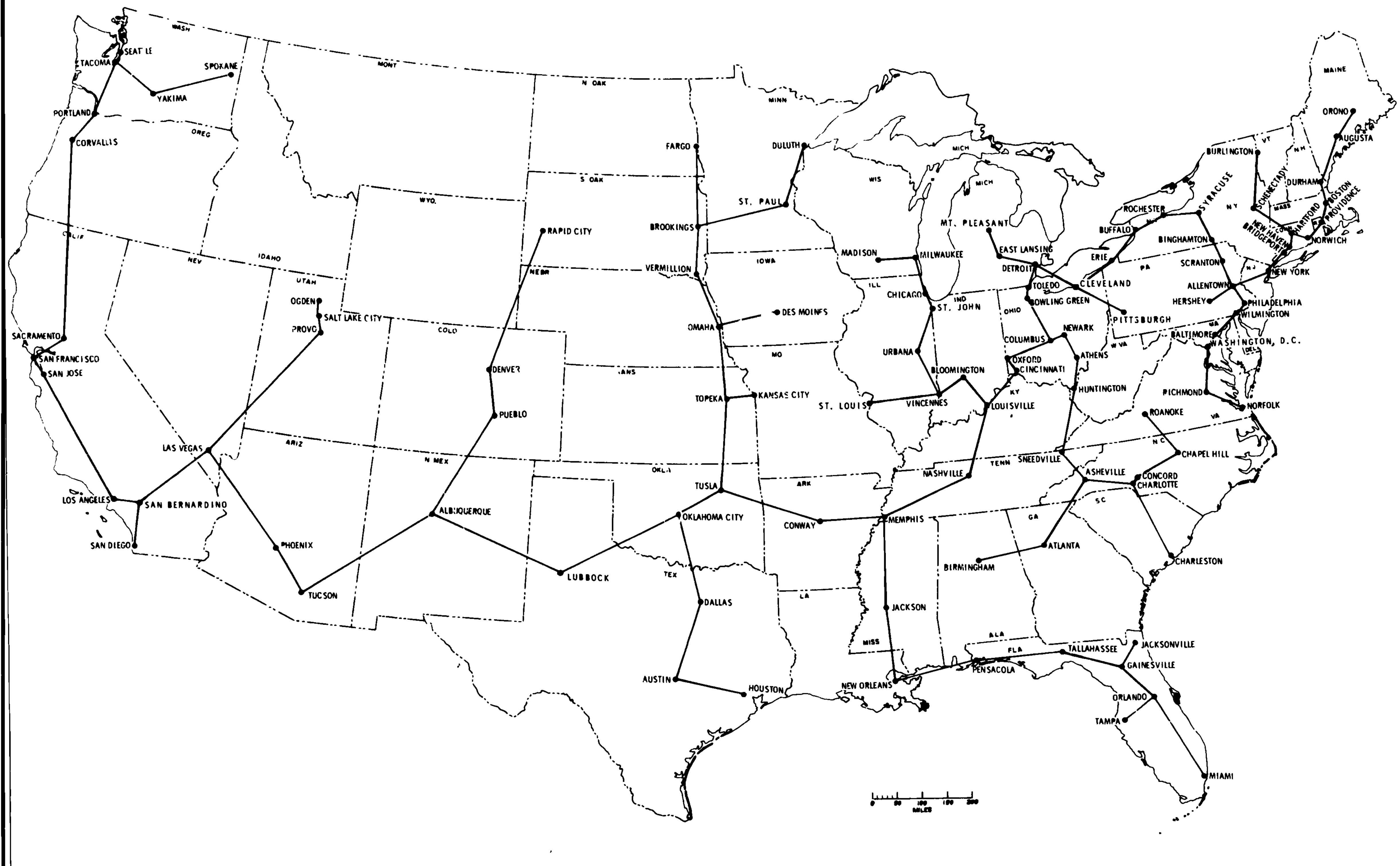

Fig. 2--Minimum distance ETV network of 106 stations

statewide ETV network; however, it can only be connected by satellite via San Francisco and falls outside the basic network problem. In addition, the rates to Hawaii are different from the Continental United States rates: The interexchange rates are $550 for the first 10 minutes and $16 per minute for each additional minute. This is equivalent to a rate of $1350 for the first hour and $960 for each additional hour. This link could be optionally included in any network serving San Francisco.

IV. ETV NETWORKING COST

Using the total intercity mileages shown on page 13, the networking costs for each of the network sizes can be estimated.* TV networking costs, utilizing the facilities and services of AT&T, have three separate components: (1) interexchange channel charges based on airline distances between cities; (2) station connecting charges for each TV station; and (3) local channel charges for connecting the TV station to the local AT&T program operating center.

Further, the rates for each of these components are given separately for the video (black and white) signal and the audio; and the audio comes in two grades of service: the 100- to 5000-cycle frequency, and the 200- to 3000-cycle frequency. Finally, the rates differ for occasional use and continuous use. For the ETV network, the following occasional-use rates will be used:†

- One way, black and white video signal (occasional use):‡
  1. Interexchange channel rate: $1 per mile per hour.
  2. Station connection charge (per station): $200 for each occasion used plus $10 per hour for each hour of use.
  3. Local channel rate (per station): $175 per month plus 15 percent of the rate for continuous service** for the first 24 hours plus 10 percent of the same for each additional 24 hours in the same month.

- One way audio, 100- to 5000-cycle frequency service (occasional use):††
  1. Interexchange channel rate: $0.15 per mile per hour

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*These costs exclude the broadcasting cost and the cost of the production of the material to be broadcast.

†All rates cited were obtained verbally by phone from Mr. D. Brinton in the Los Angeles office of AT&T on August 20, 1969.

‡No occasion may exceed 24 hours.

**The continuous service rates are given on p. 28 for the medical school network.

††For all audio cases the rates vary from location to location, but those given are representative.

plus $0.0375 per mile for each consecutive 15-minute period. Minimum charge: $2.00. Maximum charge: the continuous service rate.*

2. Station connection charge (per station): $20 per month plus $1.75 per hour.
3. Local channel rate (per station): $15 per month plus $3.45 per mile for the first week plus $6.90 per mile per week after the first week.

- One way audio, 200- to 3000-cycle frequency service (occasional use):
  1. Interexchange channel rate: $0.10 per mile for the first hour plus $0.025 per mile for each additional 15 minutes on each occasion. Minimum charge: $1.50 per mile. Maximum charge: $4.50 per mile.
  2. Station connection charge (per station): $6.25 per mile. Minimum charge: $10. Maximum charge: $20.
  3. Local channel (per station): $2.95 per mile for the first week plus $5.90 per mile per week for periods greater than one week.

In estimating the network costs, two major simplifying assumptions were made. First, it was assumed that the average local distance from the program operating center to the ETV station in each city was 15 miles and, second, that the 100- to 5000-cycle frequency audio service would be used throughout the network. This latter assumption is conservative since some of the shorter links in each network might be able to use the less expensive 200- to 3000-cycle service.

The total one-time networking cost for various network sizes for 1, 2, 3, 4, and 5 hours of one-way video and audio broadcasting is shown in Table 3. The costs for average local distances ranging from 5 to 25 miles are shown in Appendix D, together with the average costs per mile and the average cost per hour. The JOSS program used to calculate these costs is also included in this appendix.

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*The continuous service rates are given on p. 28 for the medical school network.

Table 3

TOTAL COST FOR ONE-TIME NETWORKING
($)

Number of ETV Stations	*Broadcast Hours* 1	2	3	4	5
5	6,106	9,240	12,374	15,508	18,642
10	10,267	14,589	18,911	23,233	27,555
15	14,355	19,793	25,230	30,668	36,105
20	19,003	26,116	33,229	40,343	47,456
52	41,182	51,449	61,717	71,984	82,252
106	78,098	93,179	108,260	123,342	138,423

Besides providing networking costs for the various size networks shown, these costs also point out the uneven distribution of the physician population indicated in Fig. 1. About 90 percent of the physicians within reach of the 106-ETV-station network can be reached by the 52 largest stations. This smaller network costs approximately half the 106-station network. Thus, this network, reaching a large subset of the physicians, is considerably more cost effective than total coverage, even though we have not solved for the absolute minimum way of reaching any subset of the total population.

A second interesting fact about the 106-ETV-station network illustrated in Fig. 2 is that there is no apparent significant cost saving method for regionalizing the minimum cost national network. Removal of the links between, say, Albuquerque and Lubbock, and Tulsa and Conway, would create three regions with virtually no east-west overlap. The savings, however, would amount to only $600, approximately, in total cost for each hour of broadcast (i.e., interchannel charges per mile per hour times the distances between each pair of cities). The reason for the limited cost saving opportunities from regionalization stems from the fact that there are no "clusters" or groups of cities connected from one central city in the minimum cost network. Thus, this analysis of minimum cost networks for ETV stations gives no direct indication of how one might logically regionalize the nation for communication purposes. It does, however, highlight the fact that there are large cost savings to be derived from not attempting

to attain 100 percent coverage, given the uneven distribution of the physician population.

Looking next at the cost per hour per physician (i.e., cost per potential viewer-hour) within broadcast coverage area, based on the 1966 non-Federal physician population and the 106-station network, the cost is approximately 35 cents per potential viewer-hour for 1 hour of networking and approximately 12 cents for 5 hours.

Extrapolating total physician population in the Continental United States (including osteopaths) to 1970* and assuming that the percentage of this total reached is the same as the percentage of the total 1966 non-Federal physician population reached (81.7 percent), the potential viewer population, based on all active physicians, increases from 223,583 to 260,160. In this case, the networking cost per potential viewer-hour ranges from 30 to 11 cents.

If one further assumes an average broadcast cost of $175 per hour per station, total network broadcasting cost, excluding content preparation and production, for the 106-station network becomes $96,648 for 1 hour and $231,173 for 5 hours. This results in a cost per potential viewer-hour of 37 cents for 1 hour and 18 cents for 5 hours. Moving to the 52-station network, the unit cost per potential viewer-hour, including both networking and broadcasting, reduces to 22 cents for 1 hour and 11 cents for 5 hours.

The above costs are predicated on an assumed 15-mile average local distance. A comparison of cost per potential viewer-hour for other average distances is shown in Table 4 for both the 106- and the 52-station networks. These results demonstrate that the cost per potential viewer-hour changes only 10 percent at most for a 10-mile change in average local distance.

The fact that this assumption does not significantly alter the results is important, since it indicates that minor variations in telephone company practice with respect to local channel connections would not drastically alter the results. The importance of this stems

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*J. A. Dei Rossi, et al, *A Telephone Access Biomedical Information Center*, The Rand Corporation, RM-6205-NLM, forthcoming, Winter 1970.

Table 4

NETWORK AND BROADCAST COST PER POTENTIAL VIEWER-HOUR
($)

	1 Hour of Broadcasting		*5 Hours of Broadcasting*	
Local Channel Distance (mi)	*106 Stations*	*52 Stations*	*106 Stations*	*52 Stations*
5	.33	.19	.17	.10
10	.35	.21	.18	.11
15	.37	.22	.18	.11
20	.39	.23	.18	.11
25	.41	.23	.18	.11

from the fact that these results have been calculated without verification by the telephone company of any of the specific configurations. Such verification was not sought because the purpose of this study is not to determine the precise cost of an in-place system, but rather to provide a reasonable assessment of the economic cost and potential benefit of ETV networking for the biomedical community. This provides a basis for planning and comparison with other means of information dissemination.

V. NETWORKING MEDICAL SCHOOLS

There are currently 97 accredited medical schools operating in the United States (excluding Hawaii and Puerto Rico).* However, some of the medical schools are located in the same cities and could be served by the same program operating centers; the 97 schools can be served by 72 program operating centers (POCs). A list of these POCs, ranked from largest to smallest potential population, together with the *V* and *H* coordinates for each is shown in Table 5. A full listing of the schools served by each of these centers and the total potential population reached by each is included in Appendix E. The cumulative frequency distribution of this population is plotted against the POCs in descending order of rank in Fig. 3.

Using the *V* and *H* coordinates for the POCs and the JOSS program in Appendix A, the minimum distance networks for all 72 POCs and for the largest (lowest rank) 5, 10, 15, 20 and 48 centers were calculated. The results of these calculations showing the total miles for each of the networks, the total population reached, and the percentage of the total are as follows:

Number of POCs	*Number of Schools*	*Total Miles*	*Student Population Reached*	*Percent of Total Population*
5	23	2,674	23,274	27.4
10	31	3,751	34,146	40.2
15	38	4,823	43,333	51.1
20	43	5,608	50,470	59.5
48	73	7,965	76,609	90.3
72	97	9,966	84,857	100.0

The printouts of these runs showing the links in each network, the intermediate numbers of miles, and student population reached is shown in Appendix F. A full map of the 72 program operating center

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***The Journal of the American Medical Association*, Vol. 206, No. 9, List 92, Nov. 25, 1968. Five new schools have been added: the University of California at Davis, the University of California at San Diego, the University of Connecticut, Mt. Sinai in New York, and the University of Texas at San Antonio.

Table 5

VERTICAL AND HORIZONTAL COORDINATES FOR PROGRAM OPERATING CENTERS (POCs) SERVING ALL MEDICAL SCHOOLS, RANKED BY SIZE

Program Operating Center	*Rank (largest to smallest)*	*Coordinates*	
		Vertical	*Horizontal*
New York City, N.Y.	1	4997	1406
Chicago, Ill.	2	5986	3426
Philadelphia, Pa.	3	5251	1458
Boston, Mass.	4	4422	12[illegible]9
Los Angeles, Calif.	5	9213	7878
Washington, D.C.	6	5622	1583
Minneapolis, Minn.	7	5777	4513
Ann Arbor, Mich.	8	5602	2918
Columbus, Ohio	9	5972	2555
New Orleans, La.	10	8483	2638
Seattle, Wash.	11	6336	8896
Baltimore, Md.	12	5510	1575
Indianapolis, Ind.	13	6272	2992
St. Louis, Mo.	14	6807	3482
San Francisco, Calif.	15	8492	8719
Augusta, Ga.	16	7089	1674
Iowa City, Iowa	17	6313	3972
Buffalo, N.Y.	18	5075	2326
Memphis, Tenn.	19	7471	3125
Madison, Wis.	20	5887	3796
Cleveland, Ohio	21	5574	2543
Dallas, Tex.	22	8436	4034
Detroit, Mich.	23	5536	2828
New Haven, Conn.	24	4792	1342
Kansas City, Kans.	25	7028	4212
Richmond, Va.	26	5906	1472
Albany, N.Y.	27	4639	1629
Durham, N.C.	28	6331	1499
Omaha, Nebr.	29	6687	4595

Table 5--continued

Program Operating Center	*Rank (largest to smallest)*	*Coordinates*	
		Vertical	*Horizontal*
Denver, Colo.	30	7501	5899
Atlanta, Ga.	31	7260	2083
Milwaukee, Wis.	32	5788	3589
Nashville, Tenn.	33	7010	2710
Palo Alto, Calif.	34	8562	8668
Miami, Fla.	35	8351	0527
Galveston, Tex.	36	8985	3397
Pittsburgh, Pa.	37	5621	2185
Columbia, Mo.	38	6901	3841
Chapel Hill, N.C.	39	6361	1511
Oklahoma City, Okla.	40	7947	4373
Cincinnati, Ohio	41	6263	2679
E. Lansing, Mich.	42	5584	3081
Birmingham, Ala.	43	7518	2446
Houston, Tex.	44	8938	3536
Portland, Oreg.	45	6799	8914
Rochester, N.Y.	46	4913	2195
Louisville, Ky.	47	6529	2772
Charlottesville, Va.	48	5919	1683
Syracuse, N.Y.	49	4798	1990
Salt Lake City, Utah	50	7576	7065
Lexington, Ky.	51	6459	2562
Little Rock, Ark.	52	7721	3451
Morgantown, W. Va.	53	5764	2083
Jackson, Miss.	54	8035	2880
Gainesville, Fla.	55	7838	1310
Charleston, S.C.	56	7021	1281
Loma Linda, Calif.	57	9181	7682
Winston-Salem, N.C.	58	6440	1710
Burlington, Vt.	59	4270	1808

Table 5--continued

Program Operating Center	*Rank (largest to smallest)*	*Coordinates*	
		Vertical	*Horizontal*
Jersey City, N.J.	60	5006	1409
Grand Forks, N.D.	61	5420	5300
San Antonio, Tex.	62	9225	4062
Hanover, N.H.	63	4315	1589
Providence, R.I.	64	4550	1219
Albuquerque, N. Mex.	65	8549	5887
La Jolla, Calif.	66	9445	7657
Vermillion, S.D.	67	6443	4869
Davis, Calif.	68	8316	8623
Hartford, Conn.	69	4687	1373
New Brunswick, N.J.	70	5085	1434
Hershey, Pa.	71	5337	1704
Tucson, Ariz.	72	9345	6485

SOURCE: American Telephone and Telegraph Co., Long Lines Department, *Administrative Rates and Tariffs*, Tariff FCC No. 255, New York, 1966.

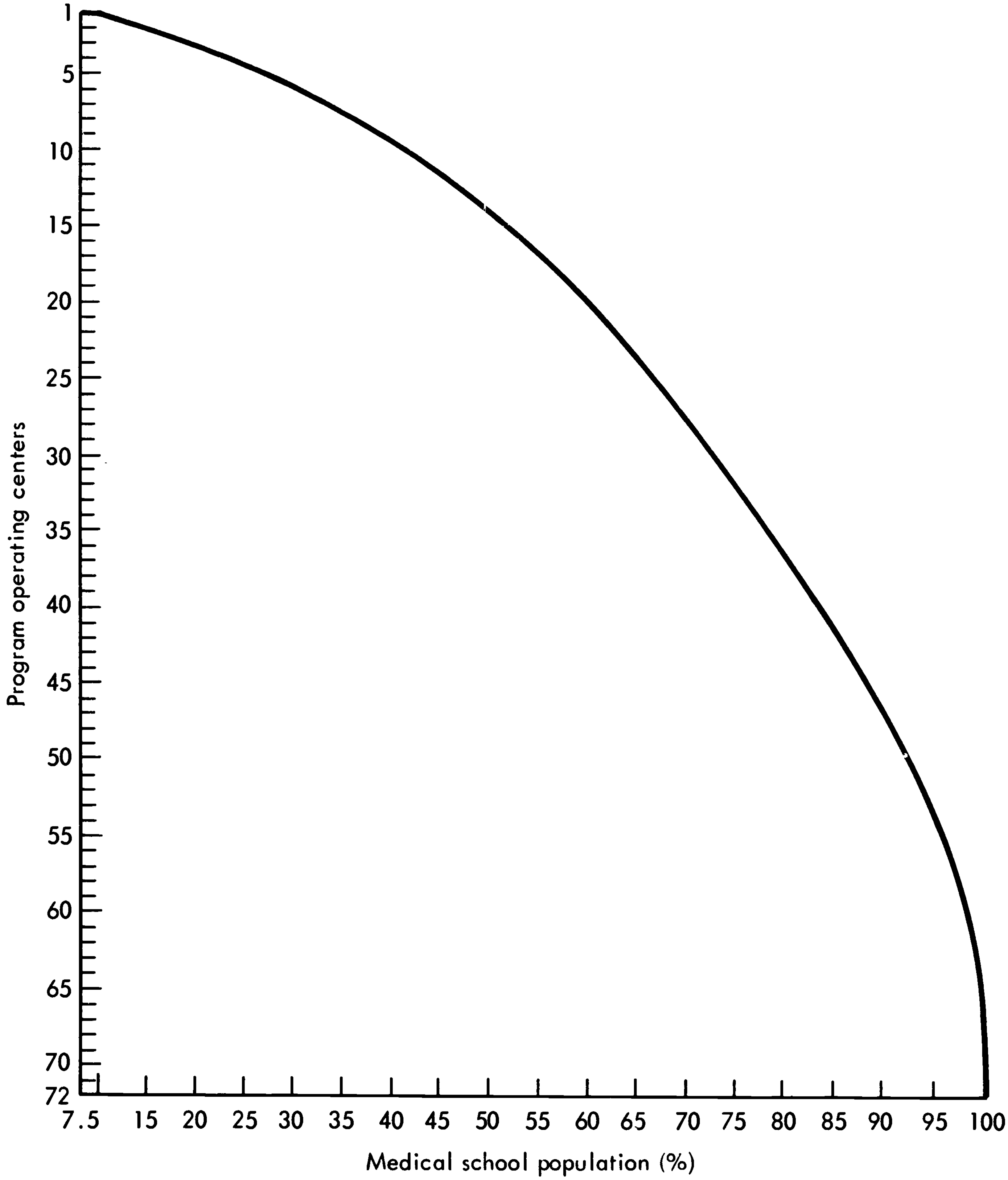

Fig. 3--Cumulative distribution of medical school population reached by 72 program operating centers

network is shown in Fig. 4. As with the ETV case, the subset of cities selected will not necessarily give the absolute minimum cost for a given audience size.

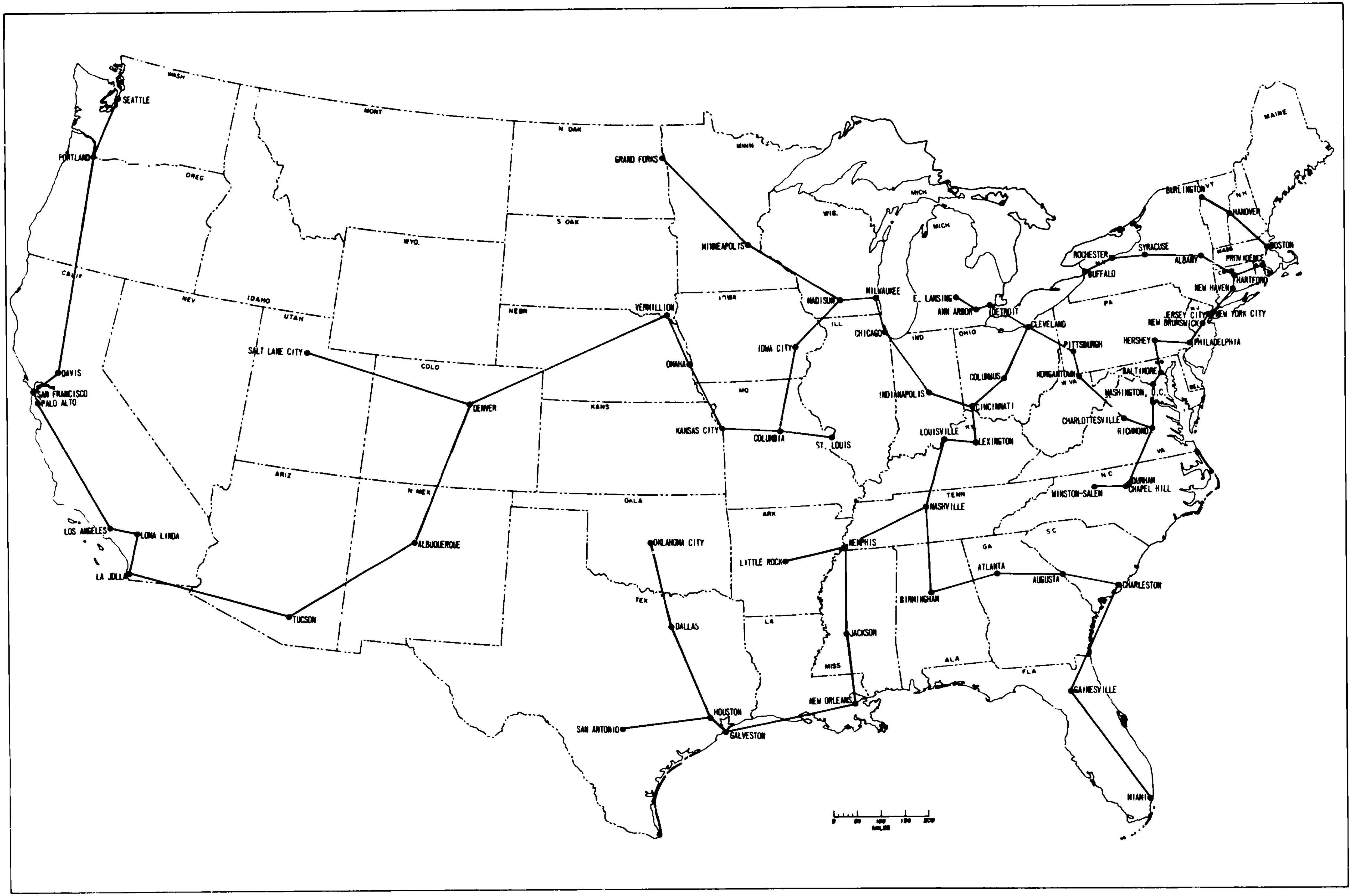

Fig. 4. Minimum distance network of 72 program operating

VI. MEDICAL SCHOOL NETWORKING COST

The same components of cost that applied to the costs of the ETV network apply to the medical school network. However, for the medical schools, the telephone company contract service (continuous-use) rates will be used. The contract service rates are monthly rates for everyday use for the stipulated number of hours per day. These rates are as follows:*

- One way, black and white video signal (continuous use):
  1. Interexchange channel rate (per month): $35 per mile for an 8-hour block of time plus $2 per mile for each additional continuous hour up to 2 hours plus $.25 per hour for each additional continuous hour on each occasion when more than 10 hours are used.
  2. Station connection charge (per station per month): $500 plus $35 per hour for the first 10 hours plus $5 an hour for each additional consecutive hour on each occasion when more than 10 hours are used.
  3. Local channel rates (per station per month): $175 plus $20 per quarter mile for the first 8 miles plus $35 per mile for miles in excess of 8.
- One way audio, 100- to 5000-cycle frequency service (continuous use):
  1. Interexchange channel rates (per month): $4.50 per mile for an 8-hour block of time plus $.25 per mile for the next continuous 3 hours plus $.15 per mile for the next 5 continuous hours.
  2. Station connection charge (per station per month): $55 for the first 8-hour block of time plus $3 for the next 3 continuous hours plus $2 for each additional hour.
  3. Local channel rate (per station per month): $15 plus $6.90 per mile.

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*As with the ETV case, these costs exclude the station broadcasting cost and the cost of production. In addition, for this case, the costs of constructing facilities for receiving and transmitting at each of the medical schools is also omitted.

- One way audio, 200- to 3000-cycle frequency service (continuous use):
  1. Interexchange channel rate (per month): $1.50 per mile for the first hour plus $.25 for each additional consecutive hour. Maximum charge: $4 per mile.
  2. Station connection charge (per station per month): $15 for the first hour plus $1.50 for each additional hour. Maximum charge: $20.
  3. Local channel rate (per month): $5.90 per mile.

In estimating the medical school network cost, the same two major assumptions used for the ETV network were made: 1) that the average local channel distance was 15 miles, and 2) that the 100- to 5000-cycle frequency audio service would be used throughout the network.

There are a number of fixed costs (i.e., costs not sensitive to the number of broadcast hours) and the interexchange channel rates buy 8-hour blocks of time, so that the total monthly networking cost difference between utilizing the network 1 hour per day and 8 hours per day is quite minimal, averaging less than 4 percent. Further, given the fact that this network would require extensive investment cost in broadcasting and receiving equipment, one would expect it to be used extensively, if at all. Therefore, only the cost of 8 hours per day of continuous broadcast networking will be described.

The following figures show the total monthly networking cost for 8 hours per day for the various size networks discussed in the preceeding section, assuming an average local distance of 15 miles: The costs for average local distances ranging from 5 to 25 miles, the average monthly cost per school, and the average monthly cost per student are

Number of Schools	*Cost ($)*
23	151,934
31	210,583
38	267,022
43	308,097
73	461,603
97	588,967

given in Appendix G. The JOSS program used to calculate these costs is also in this appendix.

As with ETV networking, these costs highlight the uneven distribution of the population shown in Fig. 3. However, in this case, the total cost saving in reaching 90 percent of the population, as opposed to 100 percent, is not as great. Approximately 90 percent of the population at the 73 largest schools (48 POCs) can be reached at a cost saving of 22 percent.

Another interesting feature of these results relates to unit costs: Total monthly cost per school and cost per student are highly insensitive to network size. The following are the average monthly continuous-networking costs per school for each size network for 8 hours per day:

Number of Schools	*Cost ($)*
23	6606
31	6793
38	7027
43	7165
73	6323
97	6072

From these figures, it can be seen that the average cost per school varies only by approximately 15 percent from the largest to the smallest network.

The following are the average monthly continuous-networking costs per student for 8 hours per day:

Number of Schools	*Cost ($)*
23,274	6.53
34,146	6.17
43,333	6.16
50,470	6.10
76,609	6.03
84,857	6.94

These costs show essentially the same insensitivity of cost per student to network size.

If one assumes that there are an average of 20 school days per month, 8 hours per day of continuous networking provides 160 hours

per month of broadcast networking. Using this figure, the network cost per potential viewer-hour is less than 5 cents for every size network and varies at most, by 10 percent for a 10-mile change in local channel distance. These cost figures, like those for the ETV network, have not been verified with the telephone company for any of the specific configurations. They are intended for planning and comparison purposes only.

Appendix A

JOSS PROGRAM FOR CALCULATING MINIMAL WEIGHTED SPANNING TREE

```
1.100 Page.
1.200 Type part 2.
1.300 Stop.
1.400 To part 5.

2.200      MINIMAL WEIGHTED SPANNING TREE
2.210
2.220 This routine selects a minimal tree connecting N points.
2.230   The N points are given by x and y coordinates.
2.240   Weights are the straight-line distances between points.
2.250
2.260 Three rules are followed in constructing the tree:
2.262     NO CIRCUITS are allowed (circuit = both endpoints already in tree)
2.264     TREE CONNECTED (unconnectivity = neither endpoint already in tree)
2.266     SHORTEST REMAINING ROUTE (minimum hyponenuse-distance)
2.269
2.270     FCC TARIFF 255 MODELED IN THIS VERSION (V AND H COORDINATES)
2.299
2.300 LIST OF VARIABLES:
2.310
2.320 n(1) = the number of points in the whole list.
2.324 n(3) = the number of points in the list to be connected this iteration.
2.326 n(4) = the number of arcs to be drawn in this tree = n(3) - 1.
2.328 n(5) = points as sources = entries in list t = current arc number.
2.330 n(6) = points as targets = entries in list u.
2.338
2.339 m(i) = number of doctors located at the ith point.
2.340 x(i) = x-coordinate of the ith point.
2.342 y(i) = y-coordinate of the ith point.
2.400 t(i) = list of sources (points already in the tree).
2.404 u(i) = list of targets (points not yet in the tree).
2.520 c(1) = current tree sum,    total distance (total cost).
2.530 c(2) = current minimal arc, distance (cost).
2.540 c(3) = current minimal arc, square of distance.
2.542 c(4) = trial arc,           square of distance.
2.550 P(1) = source of current minimal arc.
2.552 P(2) = target of current minimal arc.
2.554 Q(2) = marker one past position of P(2) in list u = condensation point.
2.560 X(i) = x-coordinate of P(i).
2.562 Y(i) = y-coordinate of P(i).

5.100 Type "SET VALUE OF n(1)".
5.200 Type "SET VALUES OF x(i), y(i), and m(i) for i=1 to n(1)".
5.300 Stop.
5.400 To part 6.

6.100 Demand n(3) as "POINTS IN THIS SUB-TREE".
6.200 Do part 7.
6.300 To step 6.100.

7.200 **** (FIND A TREE FOR n(3) POINTS).
7.201 Page.
7.202 Type form 10.
```

```
7.203 Line.
7.204 Do part 26.
7.206 Set c(1) = 0.
7.207 Set M(1) = m(1).
7.208 Set n(4) = n(3) - 1.
7.210 Do part 8 for n(5) = 1(1)n(4).

8.100 **** (DRAW AN ARC).
8.200 Set c(3) = 9· 10*10.
8.330 Set n(6) = n(3) - n(5).
8.338
8.339 **** (EXAMINE ALL SOURCE POINTS).
8.340 Do part 9 for q(1) = 1(1)n(5).
8.349
8.440 **** (OUTPUT MINIMAL ARC AND UPDATE LISTS t AND u).
8.450 Set c(2) = sqrt(c(3)/10).
8.460 Set c(1) = c(1) + c(2).
8.470 Set M(2) = m(P(2)).
8.480 Set M(1) = M(1) + M(2).
8.840 Type n(5),P(1),P(2),c(2),c(1),M(2),M(1) in form 11.
8.910 Set t(n(5)+1) = P(2).
8.920 Do part 37 for i = Q(2)(1)n(6)  if n(6) ≥ Q(2).
8.930 Set u(n(6)) = 0.

9.300 **** (EXAMINE ALL TARGET POINTS).
9.340 Do part 10 for q(2) = 1(1)n(6).

10.500 **** (TEST AND SET LOW VALUE).
10.540 Set c(4) = [x(t(q(1)))-x(u(q(2)))]*2 + [y(t(q(1)))-y(u(q(2)))]*2.
10.580 Done if c(4) ≥ c(3).
10.599
10.610 Set c(3) = c(4).
10.620 Set P(1) = t(q(1)).
10.630 Set P(2) = u(q(2)).
10.670 Set Q(2) = q(2)+1.

26.100 **** (INITIALIZE LISTS).
26.120 Set t(1) = 1.
26.140 Set u(n(1)) = 0.
26.200 Do part 36 for i = 2(1)n(1).

36.100 Set u(i-1) = i.
36.200 Set t(i) = 0.

37.020 **** (CONDENSE LIST u).
37.100 Set u(i-1) = u(i).

Form 10:
   LINE      FROM   TO       MILES     TOT MILES    MD'S   TOT MD'S

Form 11:
   ____      _____ ____    _____.__  ________.__  _____   _______
```

Appendix B

DISTRIBUTION OF NON-FEDERAL PHYSICIANS IN STANDARD METROPOLITAN STATISTICAL AREAS (SMSAs) SERVED BY ETV

	Cities Served by an ETV Station[a]	*Physicians in SMSA*	*Physicians Served per ETV Station*
1.	New York City, New York		
	New York City, N.Y.	29,388	
	Newburgh, N.Y.	268	
	Poughkeepsie, N.Y.	390	
	Jersey City, N.J.	790	
	Newark, N.J.	3,214	
	New Brunswick, N.J.	690	
	Paterson, N.J.	1,779	
	Total		36,519
2.	Los Angeles, California		
	Los Angeles, Calif.	13,068	
	Anaheim, Calif.	1,706	
	Ventura, Calif.	399	
	Total		15,173
3.	Chicago, Illinois		
	Chicago, Ill.	11,043	
	Kankakee, Ill.	117	
	Total		11,160
4.	Philadelphia, Pennsylvania		
	Philadelphia, Pa.	8,856	
	Trenton, N.J.	610	
	Vineland, N.J.	104	
	Total		9,570
5.	Boston, Massachusetts		
	Boston, Mass.	8,041	
	Brockton, Mass.	264	
	New Bedford, Mass.	427	
	Worcester, Mass.	788	
	Total		9,520
6.	San Francisco, California		
	San Francisco, Calif.	7,127	
	Santa Rosa, Calif.	295	
	Vallejo, Calif.	369	
	Total		7,791
7.	Detroit, Michigan		
	Detroit, Mich.	5,538	
	Ann Arbor, Mich.	1,078	
	Port Huron, Mich.	89	
	Total		6,705

	Cities Served by an ETV Station[a]	Physicians in SMSA	Physicians Served per ETV Station
8.	Cleveland, Ohio		
	Cleveland, Ohio	3,958	
	Akron, Ohio	841	
	Canton, Ohio	377	
	Lorain, Ohio	217	
	Sandusky, Ohio	72	
	Total		5,465
9.	Washington, D.C.		
	Washington, D.C.	4,977	
	Total		4,977
10.	Atlanta, Georgia		
	Georgia: statewide ETV	4,478	
	Chattanooga, Tenn.	385	
	Total		4,863
11.	Pittsburgh, Pennsylvania		
	Pittsburgh, Pa.	3,352	
	Johnstown, Pa.	252	
	New Castle, Pa.	81	
	Sharon, Pa.	113	
	Steubenville, Ohio	121	
	Youngstown, Ohio	626	
	Wheeling, W. Va.	225	
	Total		4,770
12.	Baltimore, Maryland		
	Baltimore, Md.	4,147	
	Total		4,147
13.	St. Paul, Minnesota		
	Minneapolis-St. Paul, Minn.	2,748	
	Rochester, Minn.	1,091	
	St. Cloud, Minn.	77	
	Eau Claire, Wis.	102	
	Total		4,018
14.	Miami, Florida		
	Miami, Fla.	2,501	
	Fort Lauderdale, Fla.	702	
	W. Palm Beach, Fla.	461	
	Total		3,664
15.	St. Louis, Missouri		
	St. Louis, Mo.	3,374	
	Total		3,374
16.	Louisville, Kentucky		
	Kentucky: statewide ETV	3,129	
	Portsmouth, Ohio	71	
	Total		3,200

Cities Served by an ETV Station[a]	*Physicians in SMSA*	*Physicians Served per ETV Station*
17. Houston, Texas		
Houston, Tex.	2,611	
Galveston, Tex.	454	
Total		3,065
18. Birmingham, Alabama		
Alabama: statewide ETV	2,867	
Biloxi, Miss.	119	
Total		2,986
19. Dallas, Texas		
Dallas, Tex.	2,054	
Fort Worth, Tex.	652	
Total		2,706
20. Seattle, Washington		
Seattle, Wash.	2,473	
Bremerton, Wash.	86	
Total		2,559
21. Milwaukee, Wisconsin		
Milwaukee, Wis.	1,956	
Fond Du Lac, Wis.	84	
Kenosha, Wis.	78	
Manitowoc, Wis.	60	
Oshkosh, Wis.	106	
Racine, Wis.	134	
Sheboygan, Wis.	80	
Total		2,498
22. Hartford, Connecticut		
Hartford, Conn.	1,524	
Middletown, Conn.	165	
Springfield, Mass.	713	
Total		2,402
23. Denver, Colorado		
Denver, Colo.	2,388	
Total		2,388
24. New Orleans, Louisiana		
New Orleans, La.	2,056	
Baton Rouge, La.	320	
Total		2,376
25. San Jose, California		
San Jose, Calif.	2,147	
Modesto, Calif.	228	
Total		2,375
26. Buffalo, New York		
Buffalo, N.Y.	2,254	
Total		2,254

	Cities Served by an ETV Station[a]	*Physicians in SMSA*	*Physicians Served per ETV Station*
27.	Cincinnati, Ohio		
	Cincinnati, Ohio	2,143	
	Total		2,143
28.	Charleston, South Carolina		
	So. Carolina: statewide ETV	2,105	
	Total		2,105
29.	East Lansing, Michigan		
	Battle Creek, Mich.	134	
	Flint, Mich.	496	
	Grand Rapids, Mich.	614	
	Jackson, Mich.	120	
	Kalamazoo, Mich.	299	
	Lansing, Mich.	351	
	Total		2,014
30.	Chapel Hill, North Carolina		
	Burlington, N.C.	81	
	Durham, N.C.	705	
	Fayetteville, N.C.	76	
	Greensboro, N.C.	294	
	Raleigh, N.C.	254	
	Rocky Mount, N.C.	78	
	Winston-Salem, N.C.	430	
	Total		1,918
31.	Kansas City, Missouri		
	Kansas City, Mo.	1,758	
	St. Joseph, Mo.	97	
	Total		1,855
32.	San Diego, California		
	San Diego, Calif.	1,835	
	Total		1,835
33.	New Haven, Connecticut		
	New Haven, Conn.	1,708	
	Total		1,708
34.	Bloomington, Indiana		
	Indianapolis, Ind.	1,550	
	Terre Haute, Ind.	152	
	Total		1,702
35.	Omaha, Nebraska		
	Nebraska: statewide ETV	1,670	
	Total		1,670
36.	Portland, Oregon		
	Portland, Oreg.	1,668	
	Total		1,668

	Cities Served by an ETV Station[a]	Physicians in SMSA	Physicians Served per ETV Station
37.	Tampa, Florida		
	Tampa, Fla.	1,184	
	Lakeland, Fla.	249	
	Sarasota, Fla.	230	
	Total		1,663
38.	Columbus, Ohio		
	Columbus, Ohio	1,503	
	Springfield, Ohio	119	
	Total		1,622
39.	Rochester, New York		
	Rochester, N.Y.	1,617	
	Total		1,617
40.	Syracuse, New York		
	Syracuse, N.Y.	1,086	
	Auburn, N.Y.	81	
	Utica, N.Y.	421	
	Total		1,588
41.	Hershey, Pennsylvania		
	Harrisburg, Pa.	530	
	Lancaster, Pa.	303	
	Lebanon, Pa.	84	
	Reading, Pa.	355	
	York, Pa.	280	
	Total		1,552
42.	Schenectady, New York		
	Albany, N.Y.	1,296	
	Pittsfield, Mass.	227	
	Total		1,523
43.	San Bernardino, California		
	San Bernardino, Calif.	1,422	
	Total		1,422
44.	Sacramento, California		
	Sacramento, Calif.	1,043	
	Stockton, Calif.	362	
	Total		1,405
45.	Bridgeport, Connecticut		
	Bridgeport, Conn.	1,321	
	Total		1,321
46.	Austin, Texas		
	Austin-San Antonio, Tex.	1,307	
	Total		1,307
47.	Memphis, Tennessee		
	Memphis, Tenn.	1,268	
	Total		1,268

	Cities Served by an ETV Station[a]	*Physicians in SMSA*	*Physicians Served per ETV Station*
48.	Providence, Rhode Island		
	Providence, R.I.	1,266	
	Total		1,266
49.	Phoenix, Arizona		
	Phoenix, Ariz.	1,232	
	Total		1,232
50.	Richmond, Virginia		
	Richmond, Va.	1,099	
	Petersburg, Va.	115	
	Total		1,214
51.	Oklahoma City, Oklahoma		
	Oklahoma City, Okla.	1,061	
	Lawton, Okla.	48	
	Total		1,109
52.	Oxford, Ohio		
	Dayton, Ohio	781	
	Hamilton, Ohio	199	
	Richmond, Ind.	83	
	Total		1,063
53.	Nashville, Tennessee		
	Nashville, Tenn.	1,024	
	Total		1,024
54.	Madison, Wisconsin		
	Madison, Wis.	834	
	Beloit, Wis.	124	
	Total		958
55.	Salt Lake City, Utah		
	Salt Lake City, Utah	897	
	Total		897
56.	Toledo, Ohio		
	Toledo, Ohio	853	
	Total		853
57.	Sneedville, Tennessee		
	Knoxville, Tenn.	533	
	Bristol, Va.	284	
	Total		817
58.	Norfolk, Virginia		
	Norfolk, Va.	581	
	Newport News, Va.	228	
	Total		809
59.	Orlando, Florida		
	Orlando, Fla.	510	
	Daytona Beach, Fla.	213	
	Total		723

	Cities Served by an ETV Station[a]	Physicians in SMSA	Physicians Served per ETV Station
60.	Conway, Arkansas		
	Little Rock, Ark.	598	
	Pine Bluff, Ark.	59	
	Total		657
61.	Allentown, Pennsylvania		
	Allentown, Pa.	646	
	Total		646
62.	Wilmington, Delaware		
	Wilmington, Del.	622	
	Total		622
63.	Scranton, Pennsylvania		
	Scranton-Wilkes-Barre, Pa.	617	
	Total		617
64.	St. John, Indiana		
	Gary, Ind.	470	
	Michigan City, Ind.	108	
	Total		578
65.	Jacksonville, Florida		
	Jacksonville, Fla.	576	
	Total		576
66.	Huntington, W. Virginia		
	Huntington, W. Va.	251	
	Charleston, W. Va.	322	
	Total		573
67.	Charlotte, North Carolina		
	Charlotte, N.C.	449	
	Gastonia, N.C.	87	
	Total		536
68.	Jackson, Mississippi		
	Jackson, Miss.	508	
	Total		508
69.	Tucson, Arizona		
	Tucson, Ariz.	502	
	Total		502
70.	Binghamton, New York		
	Binghamton, N.Y.	387	
	Elmira, N.Y.	114	
	Total		501
71.	Urbana, Illinois		
	Bloomington, Ill.	86	
	Champaign, Ill.	192	
	Danville, Ill.	82	
	Decatur, Ill.	139	
	Total		499

	Cities Served by an ETV Station[a]	Physicians in SMSA	Physicians Served per ETV Station
72.	Tulsa, Oklahoma		
	Tulsa, Okla.	477	
	Total		477
73.	Corvallis, Oregon		
	Eugene, Oreg.	227	
	Salem, Oreg.	237	
	Total		464
74.	Erie, Pennsylvania		
	Erie, Pa.	264	
	Ashtabula, Ohio	61	
	Jamestown, N.Y.	134	
	Total		459
75.	Albuquerque, New Mexico		
	Albuquerque, N. Mex.	443	
	Total		443
76.	Roanoke, Virginia		
	Roanoke, Va.	274	
	Lynchburg, Va.	155	
	Total		429
77.	Spokane, Washington		
	Spokane, Wash.	416	
	Total		416
78.	Pueblo, Colorado		
	Pueblo, Colo.	167	
	Colorado Springs, Colo.	233	
	Total		400
79.	Augusta, Maine		
	Lewiston, Maine	106	
	Portland, Maine	293	
	Total		399
80.	Tacoma, Washington		
	Tacoma, Wash.	393	
	Total		393
81.	Gainesville, Florida		
	Gainesville, Fla.	387	
	Total		387
82.	Des Moines, Iowa		
	Des Moines, Iowa	375	
	Total		375
83.	Burlington, Vermont		
	Burlington, Vt.	336	
	Total		336

	Cities Served by an ETV Station[a]	Physicians in SMSA	Physicians Served per ETV Station
84.	Topeka, Kansas		
	Topeka, Kans.	325	
	Total		325
85.	Duluth, Minnesota		
	Duluth, Minn.	308	
	Total		308
86.	Mt. Pleasant, Michigan		
	Bay City, Mich.	90	
	Saginaw, Mich.	205	
	Total		295
87.	Norwich, Connecticut		
	New London, Conn.	280	
	Total		280
88.	Vincennes, Indiana		
	Evansville, Ind.	269	
	Total		269
89.	Fargo, North Dakota		
	Fargo, N.D.	135	
	Grand Forks, N.D.	99	
	Total		234
90.	Durham, New Hampshire		
	Manchester, N.H.	220	
	Total		220
91.	Asheville, North Carolina		
	Asheville, N.C.	207	
	Total		207
92.	Las Vegas, Nevada		
	Las Vegas, Nev.	189	
	Total		189
93.	Pensacola, Florida		
	Pensacola, Fla.	182	
	Total		182
94.	Lubbock, Texas		
	Lubbock, Tex.	180	
	Total		180
95.	Athens, Ohio		
	Zanesville, Ohio	80	
	Parkersburg, W. Va.	70	
	Total		150
96.	Ogden, Utah		
	Ogden, Utah	144	
	Total		144

	Cities Served by an ETV Station[aa]	*Physicians in SMSA*	*Physicians Served per ETV Station*
97.	Concord, North Carolina		
	Kannapolis, N.C.	136	
	Total		136
98.	Bowling Green, Ohio		
	Lima, Ohio	129	
	Total		129
99.	Yakima, Washington		
	Yakima, Wash.	128	
	Total		128
100.	Vermillion, South Dakota		
	Sioux City, Iowa	127	
	Total		127
101.	Brookings, South Dakota		
	Sioux Falls, S.D.	120	
	Total		120
102.	Provo, Utah		
	Provo, Utah	118	
	Total		118
103.	Orono, Maine		
	Bangor, Maine	115	
	Total		115
104.	Tallahassee, Florida		
	Tallahassee, Fla.	99	
	Total		99
105.	Newark, Ohio		
	Newark, Ohio	73	
	Total		73
106.	Rapid City, South Dakota		
	Rapid City, S.D.	63	
	Total		63

[a]The ETV station is located in the first city listed in each group; other cities are those within range of the ETV station.

Appendix C

JOSS PRINTOUTS FOR MINIMUM TREE ETV NETWORKS

POINTS IN THIS SUB-TREE = 5

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	4	81.99	81.99	9570	46089
2	1	5	188.49	270.47	9520	55609
3	4	3	664.32	934.80	11160	66769
4	3	2	1738.79	2673.59	15173	81942

POINTS IN THIS SUB-TREE = 10

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	4	81.99	81.99	9570	46089
2	4	9	123.80	205.79	4977	51066
3	1	5	188.49	394.28	9520	60586
4	9	8	303.96	698.23	5465	66051
5	8	7	90.92	789.16	6705	72756
6	7	3	236.67	1025.82	11160	83916
7	9	10	541.58	1567.40	4863	88779
8	3	2	1738.79	3306.18	15173	103952
9	2	6	350.30	3656.49	7791	111743

POINTS IN THIS SUB-TREE = 15

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	4	81.99	81.99	9570	46089
2	4	12	89.87	171.86	4147	50236
3	12	9	35.51	207.37	4977	55213
4	1	5	188.49	395.85	9520	64733
5	9	11	190.37	586.22	4770	69503
6	11	8	114.18	700.41	5465	74968
7	8	7	90.92	791.33	6705	81673
8	7	3	236.67	1027.99	11160	92833
9	3	15	260.23	1288.22	3374	96207
10	3	13	350.04	1638.25	4018	100225
11	15	10	465.02	2103.27	4863	105088
12	10	14	600.95	2704.22	3664	108752
13	13	2	1520.83	4225.06	15173	123925
14	2	6	350.30	4575.36	7791	131716

POINTS IN THIS SUB-TREE = 20

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	4	81.99	81.99	9570	46089
2	4	12	89.87	171.86	4147	50236
3	12	9	35.51	207.37	4977	55213
4	1	5	188.49	395.85	9520	64733
5	9	11	190.37	586.22	4770	69503
6	11	8	114.18	700.41	5465	74968
7	8	7	90.92	791.33	6705	81673
8	7	3	236.67	1027.99	11160	92833
9	3	15	260.23	1288.22	3374	96207
10	15	16	241.12	1529.34	3200	99407
11	16	10	317.66	1847.00	4863	104270
12	10	18	140.83	1987.83	2986	107256
13	3	13	350.04	2337.87	4018	111274
14	15	19	543.91	2881.77	2706	113980
15	19	17	223.61	3105.38	3065	117045
16	10	14	600.95	3706.33	3664	120709
17	19	2	1240.16	4946.49	15173	135882
18	2	6	350.30	5296.80	7791	143673
19	6	20	684.08	5980.88	2559	146232

POINTS IN THIS SUB-TREE = 52

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	44	51.43	51.43	1321	37840
2	44	33	16.51	67.94	1708	39548
3	33	22	34.62	102.56	2402	41950
4	22	47	65.18	167.74	1266	43216
5	47	5	41.57	209.31	9520	52736
6	1	4	81.99	291.30	9570	62306
7	4	40	82.41	373.71	1552	63858
8	40	12	68.24	441.95	4147	68005
9	12	9	35.51	477.46	4977	72982
10	22	41	97.25	574.71	1523	74505
11	41	39	113.04	687.75	1588	76093
12	39	38	74.33	762.08	1617	77710
13	38	26	65.88	827.96	2254	79964
14	26	8	172.07	1000.03	5465	85429
15	8	7	90.92	1090.96	6705	92134
16	7	29	81.43	1172.39	2014	94148
17	8	11	114.18	1286.57	4770	98918
18	29	3	167.52	1454.09	11160	110078
19	3	21	81.10	1535.19	2498	112576
20	3	34	195.22	1730.42	1702	114278
21	34	16	75.82	1806.24	3200	117478
22	16	27	89.11	1895.35	2143	119621
23	27	51	31.43	1926.78	1063	120684
24	16	52	153.36	2080.14	1024	121708
25	52	18	181.04	2261.19	2986	124694
26	18	10	140.83	2402.02	4863	129557
27	16	49	182.24	2584.25	1117	130674
28	52	46	196.15	2780.40	1268	131942
29	34	15	200.03	2980.43	3374	135316
30	9	30	234.80	3215.23	1918	137234
31	30	28	221.02	3436.25	2105	139339
32	15	31	238.38	3674.62	1855	141194
33	31	35	164.09	3838.72	1670	142864
34	35	13	288.93	4127.65	4018	146882
35	31	50	295.85	4423.51	1109	147991
36	50	19	188.16	4611.67	2706	150697
37	19	45	180.33	4792.00	1307	152004
38	45	17	147.00	4939.00	3065	155069
39	18	24	311.14	5250.14	2376	157445
40	28	37	366.75	5616.89	1663	159108
41	37	14	203.98	5820.87	3664	162772
42	35	23	486.11	6306.98	2388	165160
43	23	48	582.30	6889.28	1232	166392
44	48	32	297.83	7187.12	1835	168227
45	32	42	97.04	7284.16	1422	169649
46	42	2	54.69	7338.85	15173	184822
47	2	25	307.57	7646.42	2375	187197
48	25	6	42.76	7689.17	7791	194988
49	6	43	73.94	7763.11	1405	196393
50	43	36	487.50	8250.61	1668	198061

POINTS IN THIS SUB-TREE = 106

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	45	51.43	51.43	1321	37840
2	45	33	16.51	67.94	1708	39548
3	33	22	34.62	102.56	2402	41950
4	22	87	35.30	137.86	280	42230
5	87	48	39.82	177.68	1266	43496
6	48	5	41.57	219.26	9520	53016
7	5	90	54.57	273.83	220	53236
8	1	61	77.85	351.68	646	53882
9	61	4	48.33	400.00	9570	63452
10	4	62	25.21	425.21	622	64074
11	61	63	56.81	482.02	617	64691
12	63	70	49.68	531.71	501	65192
13	62	12	64.77	596.48	4147	69339
14	12	9	35.51	631.99	4977	74316
15	61	41	65.88	697.87	1552	75868
16	70	40	66.66	764.53	1588	77456
17	40	39	74.33	838.86	1617	79073
18	39	26	65.88	904.74	2254	81327
19	26	74	80.97	985.71	459	81786
20	74	8	92.37	1078.08	5465	87251
21	8	7	90.92	1169.00	6705	93956
22	7	57	53.19	1222.19	853	94809
23	57	98	19.64	1241.82	129	94938
24	7	29	81.43	1323.26	2014	96952
25	29	86	60.78	1384.04	295	97247
26	9	50	96.42	1480.46	1214	98461
27	50	58	78.83	1559.29	809	99270
28	22	42	97.25	1656.54	1523	100793
29	90	79	100.03	1756.57	399	101192
30	79	103	67.13	1823.70	115	101307
31	98	38	102.60	1926.30	1622	102929
32	38	105	32.01	1958.31	73	103002
33	105	95	52.27	2010.58	150	103152
34	95	66	65.90	2076.48	573	103725
35	38	53	97.69	2174.17	1063	104788
36	53	27	31.43	2205.61	2143	106931
37	27	16	89.11	2294.72	3200	110131
38	16	34	75.82	2370.54	1702	111833
39	34	88	62.33	2432.86	269	112102
40	88	71	105.64	2538.51	499	112601
41	71	64	99.54	2638.05	578	113179
42	64	3	31.09	2669.14	11160	124339
43	3	21	81.10	2750.24	2498	126837
44	21	55	72.56	2822.80	958	127795
45	8	11	114.18	2936.98	4770	132565
46	42	83	121.07	3058.04	336	132901
47	66	51	136.10	3194.14	1117	134018

48	51	91	74.37	3268.51	207	134225
49	91	67	100.14	3368.65	536	134761
50	67	97	18.70	3387.35	136	134897
51	97	30	92.64	3479.99	1918	136815
52	30	76	105.51	3585.50	429	137244
53	88	15	144.21	3729.71	3374	140618
54	16	54	153.36	3883.07	1024	141642
55	91	10	163.66	4046.73	4863	146505
56	10	18	140.83	4187.56	2986	149491
57	67	28	175.04	4362.60	2105	151596
58	54	47	196.15	4558.75	1268	152864
59	47	60	136.20	4694.95	657	153521
60	47	68	194.45	4889.40	508	154029
61	68	24	161.02	5050.42	2376	156405
62	24	93	174.57	5224.99	182	156587
63	93	104	175.26	5400.25	99	156686
64	104	81	128.98	5529.23	387	157073
65	81	65	60.73	5589.95	576	157649
66	81	59	95.55	5685.50	723	158372
67	59	37	78.37	5763.87	1663	160035
68	59	14	202.89	5966.76	3664	163699
69	60	72	210.65	6177.41	477	164176
70	72	52	98.79	6276.20	1109	165285
71	52	19	188.16	6464.36	2706	167991
72	19	46	180.33	6644.70	1307	169298
73	46	17	147.00	6791.70	3065	172363
74	72	84	198.70	6990.40	325	172688
75	84	31	58.69	7049.09	1855	174543
76	84	35	151.66	7200.75	1670	176213
77	35	100	116.02	7316.77	127	176340
78	100	101	104.50	7421.27	120	176460
79	35	82	122.09	7543.36	375	176835
80	101	89	175.58	7718.94	237	177072
81	101	13	182.92	7901.86	4018	181090
82	13	85	134.50	8036.36	308	181398
83	52	94	277.62	8313.98	180	181578
84	94	75	292.92	8606.90	443	182021
85	75	78	245.29	8852.19	400	182421
86	78	23	103.17	8955.37	2388	184809
87	23	106	310.85	9266.22	63	184872
88	75	69	314.84	9581.06	502	185374
89	69	49	106.43	9687.48	1232	186606
90	49	92	257.00	9944.48	189	186795
91	92	43	186.13	10130.61	1422	188217
92	43	2	54.69	10185.30	15173	203390
93	43	32	97.04	10282.34	1835	205225
94	2	25	307.57	10589.91	2375	207600
95	25	6	42.76	10632.67	7791	215391
96	6	44	73.94	10706.60	1405	216796
97	92	102	336.79	11043.39	118	216914
98	102	56	37.81	11081.20	897	217811
99	56	96	32.31	11113.51	144	217955
100	44	73	427.54	11541.05	464	218419
101	73	36	72.81	11613.86	1668	220087
102	36	80	121.46	11735.32	393	220480
103	80	20	25.18	11760.50	2559	223039
104	80	[illegible]	104.14	11864.64	128	223167

Appendix D

JOSS PROGRAM AND PRINTOUTS OF COST FOR VARIOUS ETV NETWORK SIZES

This Appendix contains the JOSS program for estimating ETV networking cost and the printouts of the cost estimates for various network sizes. The program demands as inputs:

M as the miles of interchange channel.

N as number of ETV stations.

Using these inputs and the rates described in Section IV, the following variables are calculated for 1, 2, 3, 4, and 5 hours of broadcasting, and 5, 10, 15, 20, and 25 miles of local channel service.

B as video station connection cost.

G as audio station connection cost.

A as video interchange channel cost.

F as audio interchange channel cost.

D as video local channel cost.

E as audio local channel cost.

C(i,j,1) as total cost for i hours and j local channel miles.

C(i,j,2) as cost per mile for i hours and j local channel miles.

C(i,j,3) as cost per hour for i hours and j local channel miles.

JOSS PROGRAM FOR CALCULATING ETV NETWORKING COST

```
1.01 Page.
1.011 Type form 9,_,_.
1.02 Demand M as "Miles of Interchange Channel".
1.03 Demand N as "Number of ETV Stations".
1.05 Do part 2 for m=5(5)25.
1.06 Do part 4 for i=1(1)3.
1.07 To step 1.01.

2.01 Set j=m/5.
2.02 Set D=N•(175+.15•(m≤8:80•m;640+35•(m-8))).
2.021 Set E=N•(15.+3.45•m).
2.03 Do part 3 for h=1(1)5.

3.01 Set A=M•h.
3.011 Set F=.15•M•h.
3.02 Set B=N•(200+10•h).
3.021 Set G=N•(20+1.75•h).
3.03 Set V(1,j,h)=A+B+D.
3.031 Set S(1,j,h)=E+F+G.
3.032 Set C(1,j,h)=V(1,j,h)+S(1,j,h).
3.04 Set C(2,j,h)=C(1,j,h)/M.
3.05 Set C(3,j,h)=C(1,j,h)/h.

4.01 Type _,_,_,_,form 1 if i=1.
4.011 Type _,_,_ if i>1.
4.02 Type form i+1,_.
4.03 Type form 5,form 6,_.
4.04 Do part 5 for j=1(1)5 if i=1.
4.05 Do part 6 for j=1(1)5 if i=2.
4.06 Do part 7 for j=1(1)5 if i=3.

5.01 Type 5•j,C(i,j,1),C(i,j,2),C(i,j,3),C(i,j,4),C(i,j,5) in form 7.

6.01 Type 5•j,C(i,j,1),C(i,j,2),C(i,j,3),C(i,j,4),C(i,j,5) in form 8.

7.01 Type 5•j,C(i,j,1),C(i,j,2),C(i,j,3),C(i,j,4),C(i,j,5) in form 7.

Form 1:
   LOCAL

Form 2:
   MILES                    TOTAL COST

Form 3:
                          COST PER MILE

Form 4:
                          COST PER HOUR

Form 5:
                              HOURS

Form 6:
          1          2          3          4          5
```

Form 7:

— ——— ——— ——— ——— ———

Form 8:

— ——.—— ——.—— ——.—— ——.—— ——.——

Form 9:

ETV NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 12031
Number of ETV Stations = 106

TOTAL COST

LOCAL MILES	HOURS 1	2	3	4	5
5	66730	81811	96892	111973	127054
10	73487	88568	103649	118731	133812
15	78098	93179	108260	123342	138423
20	82709	97790	112871	127953	143034
25	87320	102401	117482	132564	147645

COST PER MILE

	HOURS 1	2	3	4	5
5	5.546	6.800	8.054	9.307	10.561
10	6.108	7.362	8.615	9.869	11.122
15	6.491	7.745	8.998	10.252	11.506
20	6.875	8.128	9.382	10.635	11.889
25	7.258	8.511	9.765	11.019	12.272

COST PER HOUR

	HOURS 1	2	3	4	5
5	66730	40905	32297	27993	25411
10	73487	44284	34550	29683	26762
15	78098	46590	36087	30835	27685
20	82709	48895	37624	31988	28607
25	87320	51201	39161	33141	29529

ETV NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 8397
Number of ETV Stations = 52

TOTAL COST

LOCAL MILES	HOURS 1	2	3	4	5
5	35605	45872	56140	66407	76675
10	38920	49187	59455	69722	79990
15	41182	51449	61717	71984	82252
20	43444	53711	63979	74246	84514
25	45706	55973	66241	76508	86776

COST PER MILE

	HOURS 1	2	3	4	5
5	4.240	5.463	6.686	7.908	9.131
10	4.635	5.858	7.080	8.303	9.526
15	4.904	6.127	7.350	8.573	9.795
20	5.174	6.396	7.619	8.842	10.065
25	5.443	6.666	7.889	9.111	10.334

COST PER HOUR

	HOURS 1	2	3	4	5
5	35605	22936	18713	16602	15335
10	38920	24594	19818	17431	15998
15	41182	25725	20572	17996	16450
20	43444	26856	21326	18562	16903
25	45706	27987	22080	19127	17355

ETV NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 5981
Number of ETV Stations = 20

TOTAL COST

LOCAL MILES	HOURS 1	2	3	4	5
5	16858	23971	31084	38198	45311
10	18133	25246	32359	39473	46586
15	19003	26116	33229	40343	47456
20	19873	26986	34099	41213	48326
25	20743	27856	34969	42083	49196

COST PER MILE

	HOURS 1	2	3	4	5
5	2.819	4.008	5.197	6.386	7.576
10	3.032	4.221	5.410	6.600	7.789
15	3.177	4.367	5.556	6.745	7.934
20	3.323	4.512	5.701	6.891	8.080
25	3.468	4.657	5.847	7.036	8.225

COST PER HOUR

	HOURS 1	2	3	4	5
5	16858	11986	10361	9549	9062
10	18133	12623	10786	9868	9317
15	19003	13058	11076	10086	9491
20	19873	13493	11366	10303	9665
25	20743	13928	11656	10521	9839

ETV NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 4575
Number of ETV Stations = 15

TOTAL COST

LOCAL MILES	HOURS 1	2	3	4	5
5	12746	18184	23621	29059	34496
10	13703	19140	24578	30015	35453
15	14355	19793	25230	30668	36105
20	15008	20445	25883	31320	36758
25	15660	21098	26535	31973	37410

COST PER MILE

	HOURS 1	2	3	4	5
5	2.786	3.975	5.163	6.352	7.540
10	2.995	4.184	5.372	6.561	7.749
15	3.138	4.326	5.515	6.703	7.892
20	3.280	4.469	5.657	6.846	8.034
25	3.423	4.611	5.800	6.989	8.177

COST PER HOUR

	HOURS 1	2	3	4	5
5	12746	9092	7874	7265	6899
10	13703	9570	8193	7504	7091
15	14355	9896	8410	7667	7221
20	15008	10223	8628	7830	7352
25	15660	10549	8845	7993	7482

ETV NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 3656
Number of ETV Stations = 10

TOTAL COST

LOCAL MILES	HOURS 1	2	3	4	5
5	9194	13516	17838	22160	26482
10	9832	14154	18476	22798	27120
15	10267	14589	18911	23233	27555
20	10702	15024	19346	23668	27990
25	11137	15459	19781	24103	28425

COST PER MILE

	HOURS 1	2	3	4	5
5	2.515	3.697	4.879	6.061	7.243
10	2.689	3.871	5.054	6.236	7.418
15	2.808	3.990	5.173	6.355	7.537
20	2.927	4.109	5.291	6.474	7.656
25	3.046	4.228	5.410	6.593	7.775

COST PER HOUR

	HOURS 1	2	3	4	5
5	9194	6758	5946	5540	5296
10	9832	7077	6159	5699	5424
15	10267	7294	6304	5808	5511
20	10702	7512	6449	5917	5598
25	11137	7729	6594	6026	5685

ETV NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 2674
Number of ETV Stations = 5

TOTAL COST

LOCAL MILES	HOURS 1	2	3	4	5
5	5570	8704	11838	14972	18106
10	5889	9023	12157	15290	18424
15	6106	9240	12374	15508	18642
20	6324	9458	12592	15725	18859
25	6541	9675	12809	15943	19077

COST PER MILE

	HOURS 1	2	3	4	5
5	2.083	3.255	4.427	5.599	6.771
10	2.202	3.374	4.546	5.718	6.890
15	2.284	3.456	4.628	5.800	6.971
20	2.365	3.537	4.709	5.881	7.053
25	2.446	3.618	4.790	5.962	7.134

COST PER HOUR

	HOURS 1	2	3	4	5
5	5570	4352	3946	3743	3621
10	5889	4511	4052	3823	3685
15	6106	4620	4125	3877	3728
20	6324	4729	4197	3931	3772
25	6541	4838	4270	3986	3815

Appendix E

DISTRIBUTION OF MEDICAL SCHOOL POPULATION IN 72 PROGRAM OPERATING CENTERS (POCs)

Rank	*Medical Schools Served by Each POC*	*Medical School Population*[a] *Per School*	*Medical School Population*[a] *Per POC*
1	New York City, N.Y.		
	Columbia University College of Physicians-Surgeons	1,588	
	Cornell University Medical College	776	
	Albert Einstein College of Medicine	1,229	
	New York Medical College	562	
	New York University School of Medicine	1,241	
	State University of New York Downstate Medical Center	1,834	
	Mount Sinai School of Medicine	147[b]	7,377
2	Chicago, Ill.		
	Chicago Medical School	288	
	University of Chicago School of Medicine	929	
	The University of Illinois	1,407	
	Northwestern University Medical College	1,467	
	Loyola University Stritch School of Medicine	495	4,586
3	Philadelphia, Pa.		
	Hahnemann Medical College	689	
	Jefferson Medical College	1,033	
	University of Pennsylvania School of Medicine	1,464	
	Temple University School of Medicine	841	
	Women's Medical College of Pennsylvania	321	4,348
4	Boston, Mass.		
	Boston University School of Medicine	653	
	Harvard Medical School	1,999	
	Tufts University School of Medicine	890	3,542
5	Los Angeles, Calif.		
	University of California (Irvine), California College of Medicine	591	
	UCLA School of Medicine	1,693	
	University of Southern California	1,137	3,421

Rank	Medical Schools Served by Each POC	Medical School Population[a] Per School	Per POC
6	Washington, D.C.		
	Georgetown University School of Medicine	922	
	George Washington University School of Medicine	756	
	Howard University College of Medicine	828	2,506
7	Minneapolis, Minn.		
	University of Minnesota Medical School	2,149	2,149
8	Ann Arbor, Mich.		
	University of Michigan Medical School	2,135	2,135
9	Columbus, Ohio		
	Ohio State University College of Medicine	2,097	2,097
10	New Orleans, La.		
	Louisiana State University School of Medicine	778	
	Tulane University School of Medicine	1,207	1,985
11	Seattle, Wash.		
	University of Washington	1,905	1,905
12	Baltimore, Md.		
	Johns Hopkins University School of Medicine	1,001	
	University of Maryland School of Medicine	880	1,881
13	Indianapolis, Ind.		
	Indiana University School of Medicine	1,832	1,832
14	St. Louis, Mo.		
	Saint Louis University School of Medicine	795	
	Washington University School of Medicine	1,008	1,803
15	San Francisco, Calif.		
	University of California Medical Center	1,766	1,766

Rank	Medical Schools Served by Each POC	Medical School Population[a]	
		Per School	Per POC
16	Augusta, Ga.		
	Medical College of Georgia	1,626	1,626
17	Iowa City, Iowa		
	University of Iowa, College of Medicine	1,442	1,442
18	Buffalo, N.Y.		
	State University of New York at Buffalo	1,431	1,431
19	Memphis, Tenn.		
	University of Tennessee College of Medicine	1,357	1,357
20	Madison, Wis.		
	University of Wisconsin	1,281	1,281
21	Cleveland, Ohio		
	Case Western Reserve University School of Medicine	1,280	1,280
22	Dallas, Tex.		
	University of Texas Southwest Medical School	1,082	1,082
23	Detroit, Mich.		
	Wayne State University School of Medicine	1,061	1,061
24	New Haven, Conn.		
	Yale University School of Medicine	1,048	1,048
25	Kansas City, Kans.		
	University of Kansas School of Medicine	1,022	1,022
26	Richmond, Va.		
	Medical College of Virginia	1,013	1,013
27	Albany, N.Y.		
	Albany Medical College of Union University	1,012	1,012

Rank	Medical Schools Served by Each POC	Medical School Population[a]	
		Per School	Per POC
28	Durham, N.C.		
	Duke University School of Medicine	1,012	1,012
29	Omaha, Nebr.		
	Creighton University School of Medicine	395	
	The University of Nebraska, College of Medicine	605	1,000
30	Denver, Colo.		
	University of Colorado	997	997
31	Atlanta, Ga.		
	Emory University School of Medicine	981	981
32	Milwaukee, Wis.		
	Marquette University School of Medicine	976	976
33	Nashville, Tenn.		
	Meharry Medical College	347	
	Vanderbilt University School of Medicine	600	947
34	Palo Alto, Calif.		
	Stanford University School of Medicine	914	914
35	Miami, Fla.		
	University of Miami School of Medicine	911	911
36	Galveston, Tex.		
	University of Texas Medical Branch	911	911
37	Pittsburgh, Pa.		
	University of Pittsburgh School of Medicine	906	906
38	Columbia, Mo.		
	University of Missouri School of Medicine	904	904
39	Chapel Hill, N.C.		
	University of North Carolina	900	900
40	Oklahoma City, Okla.		
	University of Oklahoma School of Medicine	892	892
41	Cincinnati, Ohio		
	University of Cincinnati College of Medicine	875	875
42	East Lansing, Mich.		
	Michigan State University College of Human Medicine	868	868

Rank	Medical Schools Served by Each POC	Medical School Population[a] Per School	Per POC
43	Birmingham, Ala. Medical College of Alabama	862	862
44	Houston, Tex. Baylor University College of Medicine	792	792
45	Portland, Oreg. University of Oregon Medical School	777	777
46	Rochester, N.Y. University of Rochester	765	765
47	Louisville, Ky. University of Louisville School of Medicine	716	716
48	Charlottesville, Va. University of Virginia Medical School	715	715
49	Syracuse, N.Y. State University of New York Upstate Medical Center	681	681
50	Salt Lake City, Utah University of Utah	670	670
51	Lexington, Ky. University of Kentucky, College of Medicine	612	612
52	Little Rock, Ark. University of Arkansas	603	603
53	Morgantown, W. Va. West Virginia University School of Medicine	602	602
54	Jackson, Miss. University of Mississippi, School of Medicine	576	576
55	Gainesville, Fla. University of Florida College of Medicine	568	568
56	Charleston, S.C. Medical College of South Carolina	531	531
57	Loma Linda, Calif. Loma Linda University School of Medicine	519	519
58	Winston-Salem, N.C. Bowman Gray School of Medicine	429	429

Rank	Medical Schools Served by Each POC	Medical School Population[a]	
		Per School	Per POC
59	Burlington, Vt. University of Vermont	399	399
60	Jersey City, N.J. New Jersey College of Medicine and Dentistry	349	349
61	Grand Forks, N.D. University of North Dakota	257	257
62	San Antonio, Tex. The University of Texas Medical School at San Antonio	245[b]	245
63	Hanover, N.H. Dartmouth Medical School	218	218
64	Providence, R.I. Brown University	206	206
65	Albuquerque, N. Mex. The University of New Mexico School of Medicine	168	168
66	La Jolla, Calif. University of California, San Diego School	167[b]	167
67	Vermillion, S.D. University of South Dakota School of Medicine	129	129
68	Davis, Calif. University of California, Davis School of Medicine	117[b]	117
69	Hartford, Conn. University of Connecticut School of Medicine	73[b]	73
70	New Brunswick, N.J. Rutgers Medical School	49	49
71	Hershey, Pa. The Pennsylvania College of Medicine	48	48

Rank	Medical Schools Served by Each POC	Medical School Population[a]	
		Per School	Per POC
72	Tucson, Ariz. University of Arizona	32	32

[a]Total Medical Population includes Medical Students; Interns; Residents; Masters, Basic Science; Doctoral, Basic Science; Postdoctoral, Basic Science; Clinical Fellows, Postdoctoral; and Medical Student equivalents in the areas of Dentistry, Pharmacy, Nursing, and other paramedicines.

[b]For these schools enrollment figures were available for medical students only and not for total population as defined above. In these cases, total population was derived by multiplying by the ratio of the average number of medical students to total population (medical) for the 92 schools for which both figures were available. That ratio was found to be 1:2.455.

Appendix F

JOSS PRINTOUTS FOR MINIMUM TREE MEDICAL SCHOOL NETWORKS

POINTS IN THIS SUB-TREE = 5

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	3	81.99	81.99	4348	11725
2	1	4	188.49	270.47	3542	15267
3	3	2	664.32	934.80	4586	19853
4	2	5	1738.79	2673.59	3421	23274

POINTS IN THIS SUB-TREE = 10

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	3	81.99	81.99	4348	11725
2	3	6	123.80	205.79	2506	14231
3	1	4	188.49	394.28	3542	17773
4	6	9	326.69	720.97	2097	19870
5	9	8	163.91	884.88	2135	22005
6	8	2	201.38	1086.26	4586	26591
7	2	7	350.04	1436.29	2149	28740
8	9	10	794.48	2230.77	1985	30725
9	7	5	1520.83	3751.61	3421	34146

POINTS IN THIS SUB-TREE = 15

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	3	81.99	81.99	4348	11725
2	3	12	89.87	171.86	1881	13606
3	12	6	35.51	207.37	2506	16112
4	1	4	188.49	395.85	3542	19654
5	6	9	326.69	722.55	2097	21751
6	9	8	163.91	886.46	2135	23886
7	9	13	167.62	1054.08	1832	25718
8	13	2	164.36	1218.44	4586	30304
9	13	14	229.42	1447.86	1803	32107
10	2	7	350.04	1797.90	2149	34256
11	14	10	593.41	2391.30	1985	36241
12	7	11	1397.25	3788.56	1905	38146
13	11	15	684.08	4472.64	1766	39912
14	15	5	350.30	4822.94	3421	43333

POINTS IN THIS SUB-TREE = 20

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	3	81.99	81.99	4348	11725
2	3	12	89.87	171.86	1881	13606
3	12	6	35.51	207.37	2506	16112
4	1	4	188.49	395.85	3542	19654
5	12	18	274.45	670.30	1431	21085
6	18	8	250.64	920.94	2135	23220
7	8	9	163.91	1084.85	2097	25317
8	9	13	167.62	1252.47	1832	27149
9	13	2	164.36	1416.84	4586	31735
10	2	20	121.12	1537.96	1281	33016
11	20	17	145.76	1683.72	1442	34458
12	17	14	220.03	1903.75	1803	36261
13	20	7	229.39	2133.13	2149	38410
14	14	19	238.40	2371.53	1357	39767
15	19	10	355.15	2726.68	1985	41752
16	9	16	449.87	3176.56	1626	43378
17	7	11	1397.25	4573.81	1905	45283
18	11	15	684.08	5257.89	1766	47049
19	15	5	350.30	5608.19	3421	50470

POINTS IN THIS SUB-TREE = 48

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	24	67.91	67.91	1048	8425
2	1	3	81.99	149.90	4348	12773
3	3	12	89.87	239.77	1881	14654
4	12	6	35.51	275.28	2506	17160
5	6	26	96.42	371.70	1013	18173
6	26	48	66.85	438.56	715	18888
7	24	27	102.85	541.40	1012	19900
8	24	4	120.64	662.05	3542	23442
9	26	28	134.67	796.72	1012	24454
10	28	39	10.22	806.93	900	25354
11	48	37	184.61	991.54	906	26260
12	37	21	114.18	1105.72	1280	27540
13	21	23	90.92	1196.65	1061	28601
14	23	8	35.29	1231.94	2135	30736
15	8	42	51.86	1283.80	868	31604
16	21	9	125.92	1409.71	2097	33701
17	9	41	100.03	1509.74	875	34576
18	41	47	89.11	1598.85	716	35292
19	41	13	99.02	1697.87	1832	37124
20	47	33	153.36	1851.24	947	38071
21	13	2	164.36	2015.60	4586	42657
22	2	32	81.10	2096.70	976	43633
23	32	20	72.56	2169.26	1281	44914
24	20	17	145.76	2315.02	1442	46356
25	21	18	172.07	2487.09	1431	47787
26	18	46	65.88	2552.97	765	48552
27	33	43	181.04	2734.01	862	49414
28	43	31	140.83	2874.84	981	50395
29	31	16	140.19	3015.03	1626	52021
30	17	38	190.50	3205.53	904	52925
31	38	14	117.35	3322.88	1803	54728
32	38	25	124.00	3446.89	1022	55750
33	25	29	162.16	3609.05	1000	56750
34	33	19	196.15	3805.20	1357	58107
35	20	7	229.39	4034.59	2149	60256
36	25	40	295.04	4329.63	892	61148
37	40	22	188.16	4517.79	1082	62230
38	22	44	223.61	4741.40	792	63022
39	44	36	46.40	4787.80	911	63933
40	36	10	287.76	5075.56	1985	65918
41	29	30	486.11	5561.67	997	66915
42	16	35	539.28	6100.95	911	67826
43	30	5	827.49	6928.44	3421	71247
44	5	34	323.71	7252.15	914	72161
45	34	15	27.39	7279.54	1766	73927
46	15	45	538.91	7818.46	777	74704
47	45	11	146.52	7964.98	1905	76609

POINTS IN THIS SUB-TREE = 72

LINE	FROM	TO	MILES	TOT MILES	MD'S	TOT MD'S
1	1	60	3.00	3.00	349	7726
2	60	70	26.20	29.20	49	7775
3	70	3	53.04	82.24	4348	12123
4	1	24	67.91	150.16	1048	13171
5	24	69	34.62	184.78	73	13244
6	69	64	65.18	249.96	206	13450
7	64	4	41.57	291.53	3542	16992
8	69	27	82.37	373.90	1012	18004
9	3	71	82.41	456.30	48	18052
10	71	12	68.24	524.55	1881	19933
11	12	6	35.51	560.05	2506	22439
12	6	26	96.42	656.48	1013	23452
13	26	48	66.85	723.33	715	24167
14	27	63	103.24	826.57	218	24385
15	63	59	70.70	897.27	399	24784
16	27	49	124.74	1022.01	681	25465
17	49	46	74.33	1096.34	765	26230
18	46	18	65.88	1162.22	1431	27661
19	26	28	134.67	1296.89	1012	28673
20	28	39	10.22	1307.10	900	29573
21	39	58	67.71	1374.81	429	30002
22	48	53	135.66	1510.47	602	30604
23	53	37	55.55	1566.01	906	31510
24	37	21	114.18	1680.19	1280	32790
25	21	23	90.92	1771.12	1061	33851
26	23	8	35.29	1806.41	2135	35986
27	8	42	51.86	1858.27	868	36854
28	21	9	125.92	1984.18	2097	38951
29	9	41	100.03	2084.21	875	39826
30	41	51	72.18	2156.40	612	40438
31	51	47	70.00	2226.40	716	41154
32	41	13	99.02	2325.42	1832	42986
33	47	33	153.36	2478.78	947	43933
34	13	2	164.36	2643.14	4586	48519
35	2	32	81.10	2724.24	976	49495
36	32	20	72.56	2796.80	1281	50776
37	20	17	145.76	2942.56	1442	52218
38	33	43	181.04	3123.60	862	53080
39	43	31	140.83	3264.43	981	54061
40	31	16	140.19	3404.62	1626	55687
41	16	56	126.12	3530.74	531	56218
42	17	38	190.50	3721.24	904	57122
43	38	14	117.35	3838.60	1803	58925
44	38	25	124.00	3962.60	1022	59947
45	25	29	162.16	4124.76	1000	60947
46	29	67	116.02	4240.79	129	61076
47	33	19	196.15	4435.94	1357	62433
48	19	52	129.91	4566.85	603	63036
49	19	54	194.45	4761.30	576	63612
50	54	10	161.02	4922.32	1985	65597
51	20	7	229.39	5151.71	2149	67746
52	56	55	258.52	5410.23	568	68314

(Cont.)

53	7	61	273.28	5683.51	257	68571
54	10	36	287.76	5971.28	911	69482
55	36	44	46.40	6017.68	792	70274
56	44	62	189.48	6207.16	245	70519
57	44	22	223.61	6430.77	1082	71601
58	22	40	188.16	6618.93	892	72493
59	55	35	296.02	6914.95	911	73404
60	67	30	466.93	7381.88	997	74401
61	30	65	331.43	7713.31	168	74569
62	65	72	314.84	8028.14	32	74601
63	30	50	369.48	8397.63	670	75271
64	72	66	371.97	8769.59	167	75438
65	66	57	83.86	8853.45	519	75957
66	57	5	62.80	8916.25	3421	79378
67	5	34	323.71	9239.96	914	80292
68	34	15	27.39	9267.35	1766	82058
69	15	68	63.40	9330.75	117	82175
70	68	45	488.46	9819.21	777	82952
71	45	11	146.52	9965.74	1905	84857

Appendix G

JOSS PROGRAM AND PRINTOUTS OF COSTS FOR VARIOUS SIZE MEDICAL SCHOOL NETWORKS

This Appendix contains the JOSS program for estimating Medical School networking cost and the printouts of the cost estimates for various network sizes. The program demands:

> M as the miles of interchange channels.
>
> N as the number of medical schools.
>
> Z as the number of months.
>
> Y as the number of medical students.

Using these inputs and the rates described in Section VI, the following variables are calculated for 1, 2, 4, 6, and 8 hours of broadcasting, and 5, 10, 15, 20, and 25 miles of local channel

> B as video station connection cost.
>
> G as audio station connection cost.
>
> A as video interchange channel cost.
>
> E as audio interchange channel cost.
>
> D as video local channel cost.
>
> E as audio local channel cost.
>
> $C(1,j,n)$ as total cost for n schools and j local channel miles.
>
> $C(2,j,n)$ as cost per school for n schools and j local channel miles.
>
> $C(3,j,n)$ as cost per student for n schools and j local channel miles.

JOSS PROGRAM FOR CALCULATING MEDICAL SCHOOL NETWORKING COST

```
1.01 Page.
1.02 Type form 9, form 10, form 11, _,_.
1.03 Set h=8.
1.05 Do part 10 for m=5(5)25.
1.07 Do part 4 for i=1(1)3.
1.08 Do step 1.01.

2.02 Set D=N(n)•(175+(m≤8:80•m;640+35•(m-8))).
2.03 Set E=N(n)•(15+6.9•m).
2.04 Do part 3.

3.01 Set A=M(n)•(h≤8:35).
3.011 Set F=M(n)•(h≤8:4.5).
3.02 Set B=N(n)•(h≤10:500+35•h).
3.021 Set G=N(n)•(h≤8:55).
3.03 Set V(1,j,n)=A+B+D.
3.031 Set S(1,j,n)=E+F+G.
3.032 Set C(1,j,n)=V(1,j,n)+S(1,j,n).
3.04 Set C(2,j,n)=C(1,j,n)/N(n).
3.05 Set C(3,j,n)=C(1,j,n)/Y(n).

4.01 Type _,_,_,_,form 1 if i=1.
4.011 Type _,_,_ if i>1.
4.02 Type form i+1,_.
4.03 Type form 5,form 6,_.
4.04 Do part 5 for j=1(1)5 if i=1.
4.05 Do part 6 for j=1(1)5 if i=2.
4.06 Do part 7 for j=1(1)5 if i=3.

5.01 Type 5•j,C(i,j,1),C(i,j,2),C(i,j,3),C(i,j,4),C(i,j,5),C(i,j,6) in form 7.

6.01 Type 5•j,C(i,j,1),C(i,j,2),C(i,j,3),C(i,j,4),C(i,j,5),C(i,j,6) in form 8.

7.01 Type 5•j,C(i,j,1),C(i,j,2),C(i,j,3),C(i,j,4),C(i,j,5),C(i,j,6) in form 8.

10.1 Set j=m/5.
10.2 Do part 2 for n=1(1)6.

Form 1:
   LOCAL

Form 2:
   MILES                      TOTAL COST

Form 3:
                          COST PER SCHOOL

Form 4:
                          COST PER STUDENT

Form 5:
                        NUMBER OF SCHOOLS IN NETWORK
```

Form 6:

23 31 38 43 73 97

Form 7:

__ ______ ______ ______ ______ ______ ______

Form 8:

__ ____.__ ____.__ ____.__ ____.__ ____.__ ____.__

Form 9:

MONTHLY NEDICAL SCHOOL NETWORKING COST

Form 10:

EIGHT HOURS PER DAY

Form 11:

(DOLLARS)

M(n): [n=1:2674;n=2:3751;n=3:4823;n=4:5608;n=5:7965;n=6:9966]
N(n): [n=1:23;n=2:31;n=3:38;n=4:43;n=5:73;n=6:97]
Y(n): [n=1:23274;n=2:34146;n=3:43333;n=4:50470;n=5:76609;n=6:84857]

MONTHLY MEDICAL SCHOOL NETWORKING COST
EIGHT HOURS PER DAY
(DOLLARS)

TOTAL COST

LOCAL MILES	NUMBER OF SCHOOLS IN NETWORK 23	31	38	43	73	97
5	139192	193409	245970	284275	421161	535229
10	147115	204089	259061	299088	446310	568645
15	151934	210583	267022	30809[illegible]	461603	588967
20	156752	217078	274983	317105	476897	609288
25	161571	223572	282944	326114	492190	629610

COST PER SCHOOL

LOCAL MILES	NUMBER OF SCHOOLS IN NETWORK 23	31	38	43	73	97
5	6051.80	6239.00	6472.88	6611.03	5769.33	5517.82
10	6396.30	6583.50	6817.38	6955.53	6113.83	5862.32
15	6605.80	6793.00	7026.88	7165.03	6323.33	6071.82
20	6815.30	7002.50	7236.38	7374.53	6532.83	6281.32
25	7024.80	7212.00	7445.88	7584.03	6742.33	6490.82

COST PER STUDENT

LOCAL MILES	NUMBER OF SCHOOLS IN NETWORK 23	31	38	43	73	97
5	5.98	5.66	5.68	5.63	5.50	6.31
10	6.32	5.98	5.98	5.93	5.83	6.70
15	6.53	6.17	6.16	6.10	6.03	6.94
20	6.74	6.36	6.35	6.28	6.23	7.18
25	6.94	6.55	6.53	6.46	6.42	7.42

MEDICAL SCHOOL NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 7965
Number of Medical Schools = 73
Number of Months = 1
Number of Medical Students = 76609

TOTAL COST

LOCAL MILES	HOURS 1	2	4	6	8
5	403276	682051	1239601	1797151	2354701
10	428425	707200	1264750	1822300	2379850
15	443718	722493	1280043	1837593	2395143
20	459012	737787	1295337	1852887	2410437
25	474305	753080	1310630	1868180	2425730

COST PER SCHOOL

LOCAL MILES	HOURS 1	2	4	6	8
5	5524.33	9343.16	16980.84	24618.51	32256.18
10	5868.83	9687.66	17325.34	24963.01	32600.68
15	6078.33	9897.16	17534.84	25172.51	32810.18
20	6287.83	10106.66	17744.34	25382.01	33019.68
25	6497.33	10316.16	17953.84	25591.51	33229.18

COST PER STUDENT

LOCAL MILES	HOURS 1	2	4	6	8
5	5.26	8.90	16.18	23.46	30.74
10	5.59	9.23	16.51	23.79	31.06
15	5.79	9.43	16.71	23.99	31.26
20	5.99	9.63	16.91	24.19	31.46
25	6.19	9.83	17.11	24.39	31.66

MEDICAL SCHOOL NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 5608
Number of Medical Schools = 43
Number of Months = 1
Number of Medical Students = 50470

TOTAL COST

LOCAL MILES	HOURS 1	2	4	6	8
5	273740	470020	862580	1255140	1647700
10	288553	484833	877393	1269953	1662513
15	297562	493842	886402	1278962	1671522
20	306570	502850	895410	1287970	1680530
25	315579	511859	904419	1296979	1689539

COST PER SCHOOL

LOCAL MILES	HOURS 1	2	4	6	8
5	6366.03	10930.69	20059.99	29189.29	38318.59
10	6710.53	11275.19	20404.49	29533.79	38663.09
15	6920.03	11484.69	20613.99	29743.29	38872.59
20	7129.53	11694.19	20823.49	29952.79	39082.09
25	7339.03	11903.69	21032.99	30162.29	39291.59

COST PER STUDENT

LOCAL MILES	HOURS 1	2	4	6	8
5	5.42	9.31	17.09	24.87	32.65
10	5.72	9.61	17.38	25.16	32.94
15	5.90	9.78	17.56	25.34	33.12
20	6.07	9.96	17.74	25.52	33.30
25	6.25	10.14	17.92	25.70	33.48

MEDICAL SCHOOL NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 4823
Number of Medical Schools = 38
Number of Months = 1
Number of Medical Students = 43333

TOTAL COST

LOCAL MILES	HOURS 1	2	4	6	8
5	236660	405465	743075	1080685	1418295
10	249751	418556	756166	1093776	1431386
15	257712	426517	764127	1101737	1439347
20	265673	434478	772088	1109698	1447308
25	273634	442439	780049	1117659	1455269

COST PER SCHOOL

LOCAL MILES	HOURS 1	2	4	6	8
5	6227.88	10670.12	19554.59	28439.07	37323.54
10	6572.38	11014.62	19899.09	28783.57	37668.04
15	6781.88	11224.12	20108.59	28993.07	37877.54
20	6991.38	11433.62	20318.09	29202.57	38087.04
25	7200.88	11643.12	20527.59	29412.07	38296.54

COST PER STUDENT

LOCAL MILES	HOURS 1	2	4	6	8
5	5.46	9.36	17.15	24.94	32.73
10	5.76	9.66	17.45	25.24	33.03
15	5.95	9.84	17.63	25.42	33.22
20	6.13	10.03	17.82	25.61	33.40
25	6.31	10.21	18.00	25.79	33.58

MEDICAL SCHOOL NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 3751
Number of Medical Schools = 31
Number of Months = 1
Number of Medical Students = 34146

TOTAL COST

LOCAL MILES	HOURS 1	2	4	6	8
5	185814	317099	579669	842239	1104809
10	196494	327779	590349	852919	1115489
15	202988	334273	596843	859413	1121983
20	209483	340768	603338	865908	1128478
25	215977	347262	609832	872402	1134972

COST PER SCHOOL

LOCAL MILES	HOURS 1	2	4	6	8
5	5994.00	10229.00	18699.00	27169.00	35639.00
10	6338.50	10573.50	19043.50	27513.50	35983.50
15	6548.00	10783.00	19253.00	27723.00	36193.00
20	6757.50	10992.50	19462.50	27932.50	36402.50
25	6967.00	11202.00	19672.00	28142.00	36612.00

COST PER STUDENT

LOCAL MILES	HOURS 1	2	4	6	8
5	5.44	9.29	16.98	24.67	32.36
10	5.75	9.60	17.29	24.98	32.67
15	5.94	9.79	17.48	25.17	32.86
20	6.13	9.98	17.67	25.36	33.05
25	6.33	10.17	17.86	25.55	33.24

MEDICAL SCHOOL NETWORKING COST (DOLLARS)

Miles of Interchange Channel = 2674
Number of Medical Schools = 23
Number of Months = 1
Number of Medical Students = 23274

TOTAL COST

LOCAL MILES	HOURS 1	2	4	6	8
5	133557	227147	414327	601507	788687
10	141480	235070	422250	609430	796610
15	146299	239889	427069	614249	801429
20	151117	244707	431887	619067	806247
25	155936	249526	436706	623886	811066

COST PER SCHOOL

LOCAL MILES	HOURS 1	2	4	6	8
5	5806.80	9875.93	18014.20	26152.46	34290.72
10	6151.30	10220.43	18358.70	26496.96	34635.22
15	6360.80	10429.93	18568.20	26706.46	34844.72
20	6570.30	10639.43	18777.70	26915.96	35054.22
25	6779.80	10848.93	18987.20	27125.46	35263.72

COST PER STUDENT

LOCAL MILES	HOURS 1	2	4	6	8
5	5.74	9.76	17.80	25.84	33.89
10	6.08	10.10	18.14	26.19	34.23
15	6.29	10.31	18.35	26.39	34.43
20	6.49	10.51	18.56	26.60	34.64
25	6.70	10.72	18.76	26.81	34.85

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